ILLUMINATING ENGINEERING

JUNE 1953

School Lighting

THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

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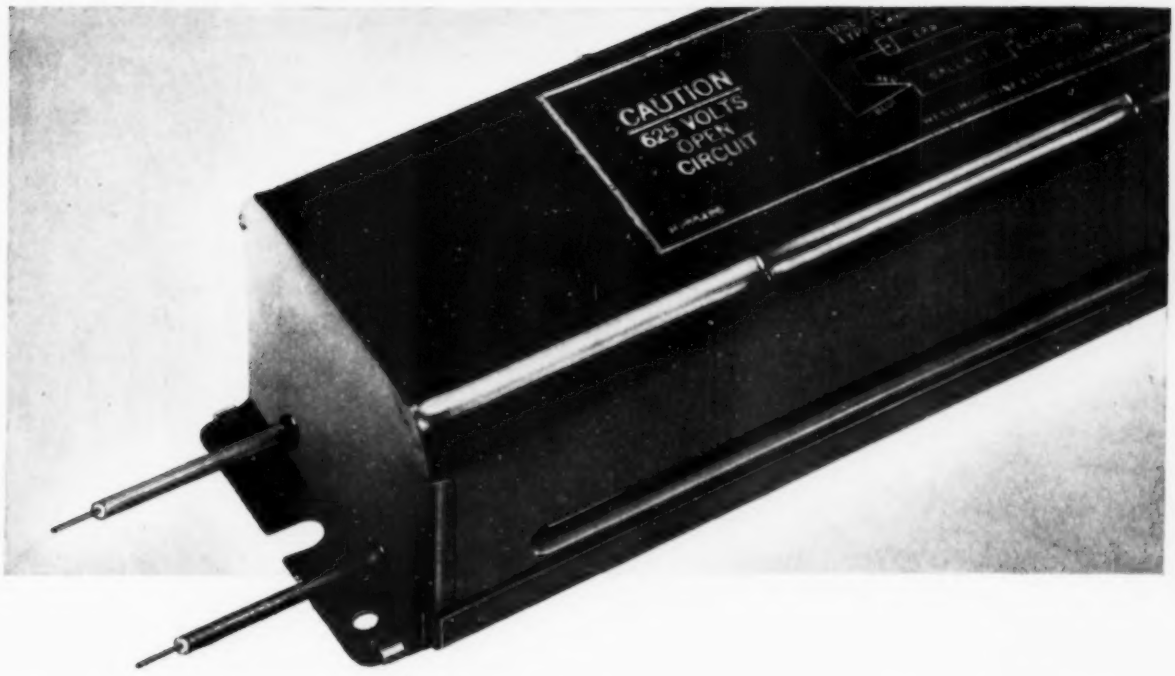

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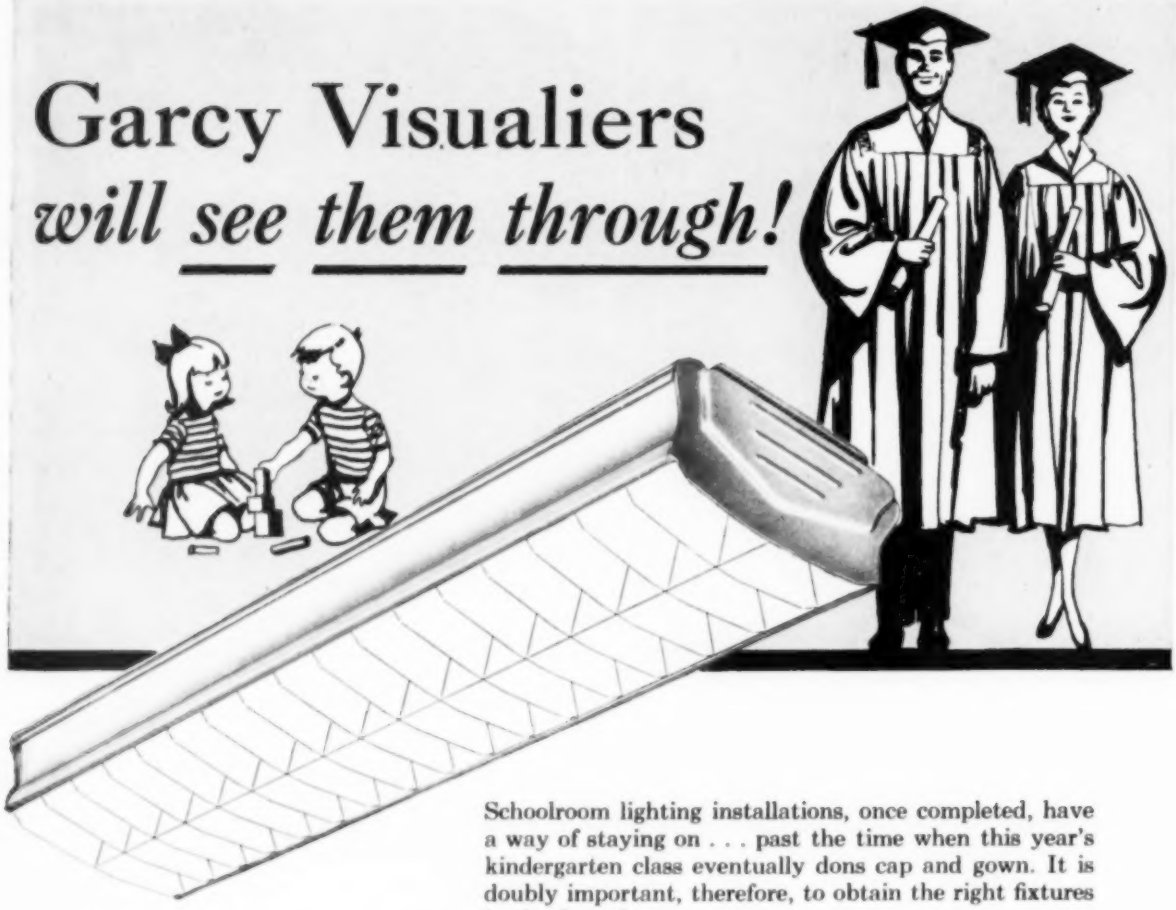

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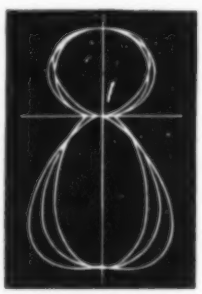

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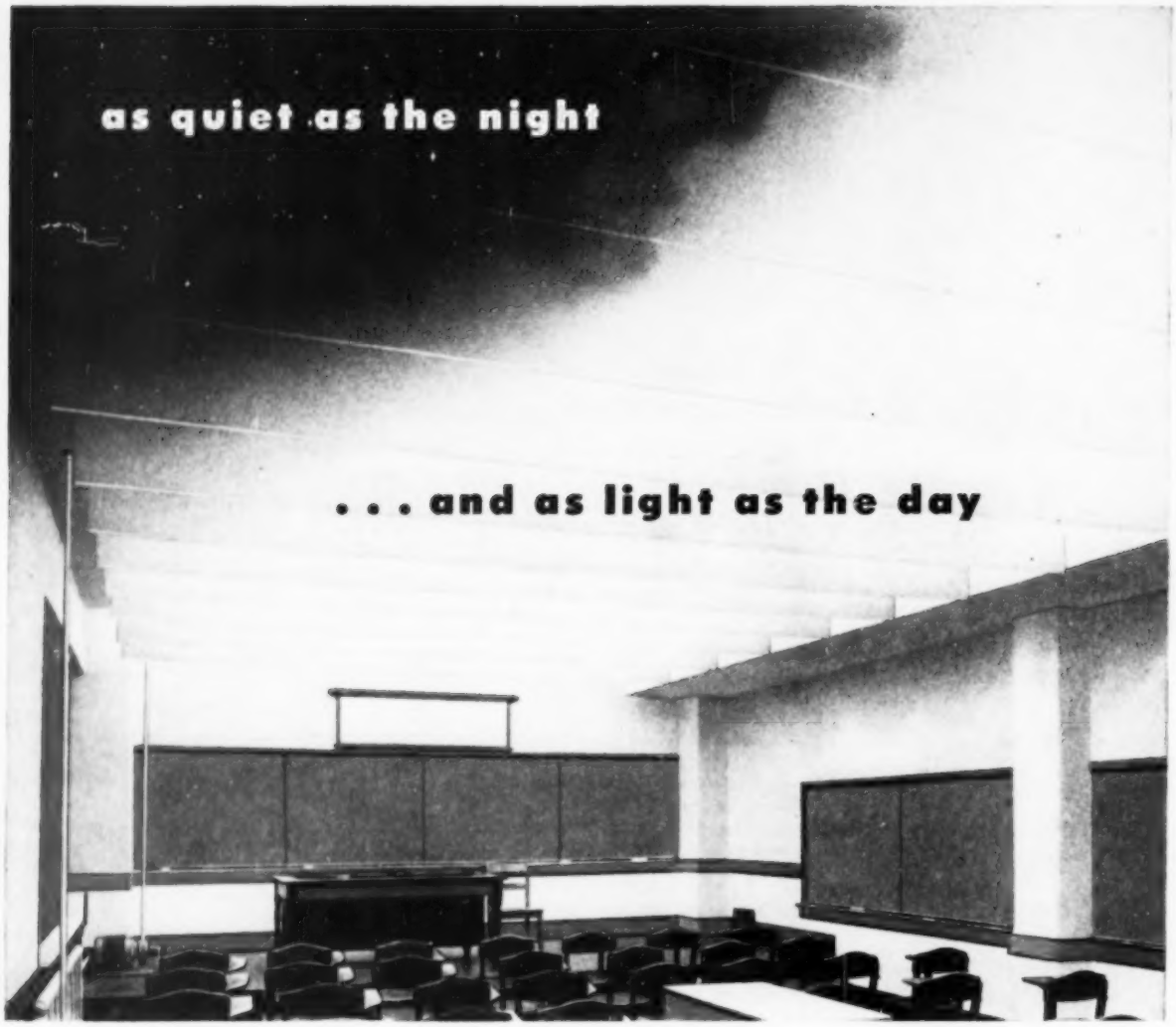

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Correlation of Lighting Goals With School Building Design

By CHARLES D. GIBSON
FOSTER K. SAMPSON

Frame of Reference

Today any discussion of lighting or lighting design should be prefaced with a frame of reference. As the lighting field has become more and more complicated by the introduction of new sources, new applications of old sources and a multiplicity of new materials and techniques, it becomes increasingly necessary for a speaker or author to define the thinking against which he is basing his case if he wishes to communicate clearly to his audience. The following group of one-sentence statements creates the frame of reference for this article. The sum of these statements establishes the points-of-view of the authors and reflects their research and experience.

¶ Brightness balance instead of high footcandle levels is the prime consideration in establishing an acceptable visual environment for critical seeing tasks.

¶ Visual comfort and efficiency depends upon establishing and maintaining maximum and minimum brightness differences between the *task* and areas of high brightness and between the *task* and areas of low brightness in a 360-degree visual field.

¶ No inhibitions should be placed upon seating or other work stations arrangements within the room in an effort to establish visual comfort.

¶ High levels of illumination without brightness control do not mean a better visual environment.

¶ Sky brightness and ground brightness are the two major daylight sources and both must be controlled in order to produce a positive visual environment for critical seeing tasks.

¶ The use of ground brightness as an effective daylight source can be a part of the planned design of the building.

¶ The function of electric lighting is to supplement or replace daylighting.

¶ Both general light sources should be subjected to the same brightness limitations and the design of both sources should be coordinated to provide acceptable performance from both in the completed structure.

¶ Maintenance problems created by lighting design must be held to a minimum.

AUTHORS: Division of Public School Administration, State of California Department of Education and F. K. Sampson Co., Illuminating Engineers, respectively

¶ Progress in daylight design depends not only upon the development of more effective classroom sections but also upon the planned and intelligent integration of all the buildings in a school plant into patterns which guarantees adequate daylight sources as well as sky brightness control.

¶ Orientation of buildings alone will not solve the problems of brightness-balance.

¶ The building design develops from the correlation of interior and exterior elements which, in combination, produce a comfortable and efficient visual environment.

Lighting Goals

The lighting goals established by the National Council on Schoolhouse Construction are listed here because they reflect the above frame-of-reference, they are realistic in terms of visual comfort and efficiency, and follow closely the general recommendations of the Quantity and Quality Committee of the Illuminating Engineering Society.

"*Goal A* — The footlambert brightness of any surface viewed from any normal standing or sitting position in the schoolroom should not exceed ten times the footlambert brightness of the poorest lighted task in the room.

Goal B — The footlambert brightness of any surface viewed from any normal standing or sitting position in the schoolroom should not be less than one-third the footlambert brightness of the poorest lighted task in the room.

Goal C — The footlambert brightness of any surface immediately adjacent to the task should not exceed three times the task brightness.

Goal D — Brightness-difference between adjacent surfaces should be reduced to a minimum.

Goal E — The brightness goals stated above assume a lighting system that provides from twenty to forty footcandles on the poorest lighted task. As footcandle levels are increased, sources of high brightnesses should be controlled to more nearly approach the brightness of the task. The extent of the area of the surface producing brightness has a measurable effect upon visual comfort. Small areas of either extreme of brightness generally are less noticeable than large areas of the same brightness.

The term, *task*, as used in the above definitions of goals, is interpreted to include *any* visual task which may be encountered in a schoolroom. For example, a "task" might be a book on the student's desk; the written symbols on the chalkboard; demonstration or experimental apparatus in a laboratory; an art assignment on an easel or exhibit material on a tackboard; a motion picture or a lantern slide. On the basis of this concept, it is apparent that the tasks may be in either a horizontal or a vertical plane and may require the student to face in any direction. Visual tasks in schoolrooms range in brightness difference from reading black symbols on white paper to sewing with black thread on black cloth. Other factors remaining constant, visual comfort and efficiency increase with the increase in brightness-difference within the task."

The problem of attaining Goals B, C and D is a matter of proper finishes and colors of the room interiors and furnishings. The progress that has been made and the nation-wide acceptance of these three goals is evident in that most current work conforms to them.

Goal E which is concerned with light intensities, varies with each solution and recommends lower brightness-differences than stated in Goal A when footcandle levels are increased.

Goal A, on the other hand, is the basis for most of our concern. It is apparent that the brightness of unshielded sky and lighting fixtures must be controlled to a greater degree if they are to come within the range of comfort established by this goal.

Both daylight and electric light sources must be thought of as being subject to the same brightness limitations. It is not logical to insist upon low brightness lighting fixtures for classrooms and, at the same time, tolerate unshielded sky-brightness. Both of these potential glare sources must be brought within the limitations of Goal A.

Even with light intensities of fifty to sixty foot-

TABLE I.—Approximate Brightnesses Found in Classrooms.

	Footlamberts
Clear sky	1000
Hazy sky	1000-6000
White clouds	3000-8000
Sunlight on white building	5000-8000
Sunlight on trees	75-1000
Bare 200-watt filament lamp	65,000
Opal glass enclosing globe	800-1200
Bare T12 fluorescent lamp	1400-1900
Louvered fluorescent fixture	400-1200
Luminous indirect fluorescent fixture	175
White ceiling above indirect incandescent fixture	
500-watt — 30" from ceiling	110-130
500-watt — 42" from ceiling	60-80
750-watt — 48" from ceiling	95-120
1000-watt — 48" from ceiling	120-160
Average task — 30 ft-c on 70% R.F.	21
Desk top — 30 ft-c on 50% R.F.	15
Floor — 20 ft-c on 30% R.F.	6
Tackboard — 50 ft-c on 50% R.F.	25
Chalkboard — 50 ft-c on 30% R.F.	15
Walls — 30 ft-c to 200 ft-c on 75% R.F.	23-150
Green grass — 6000 ft-c on 20% R.F.	1200
Dry grass — 6000 ft-c on 30% R.F.	1800
Bare dry ground — 6000 ft-c on 25% R.F.	1500
Concrete — 6000 ft-c on 55% R.F.	3300
Macadam — 6000 ft-c on 18% R.F.	1080
Fresh snow — 6000 ft-c on 100% R.F.	6000
Desert sand — 10,000 ft-c on 50% R.F.	5000

East Wall

West Wall

School: Andrus Duarte, Duarte, Calif.

Architects: Allison and Rible, Los Angeles, Calif.

Photographer: Robert C. Cleveland

Profile section (below) through classroom wings shows the critical sight-lines as they are related to fixed interior and exterior louvers and adjacent buildings for sky-brightness shielding. Corridors and low windows are on the east exposure. Windows above the corridor roof are shielded by vertical interior louvers. Electric lighting is provided by concentric-ring luminaires, and by reflector lamps mounted next to the window sill above the interior louvers. Table and chair furniture frees educationally valuable floor area and permits flexible seating arrangements.

candles an average task brightness of approximately forty footlamberts is produced. This means that a *maximum* of four hundred footlamberts in a 360-degree visual field is permitted by Goal A.

The problem of selecting a lighting fixture which has a brightness of less than four hundred footlamberts is made relatively easy by the brightness reports of the Electrical Testing Laboratory.

Area Brightnesses Common to Classrooms*

The footlambert figures given in Table I are approximate values for some of the brightnesses found in classrooms. Variable factors may cause actual readings to be considerably different, either higher or lower. For example sky brightness is affected by the time of the year, the time of day, weather conditions and the latitude of the location. The brightness of sunlit objects depends upon the intensity of the sun and the reflection factor of the object. Lighting fixtures of different manufacturers, even of the same basic type, may have brightness characteristics which are considerably different. Interior reflecting surfaces will have brightnesses which are dependent upon the reflection factor of the surface and light intensity on the surface. For these reasons an observer attempting to evaluate lighting conditions must be careful either to measure accurately, or to make studied estimates based upon actual conditions and experience. The table may be used as a basis for estimating, but the values given for variable items are only approximate.

The problem of conditioning a classroom for visual comfort and efficiency is to modify these brightnesses to bring the total environment within the range of recommended brightness-differences as expressed in Goals A through E. The following illustrations show interiors and exteriors of school buildings which were designed in an attempt to meet the requirements of Goals A through E.

*Credit is given by the authors for this section, "Area Brightness Common to Classrooms," to the National Council on Schoolhouse Construction.

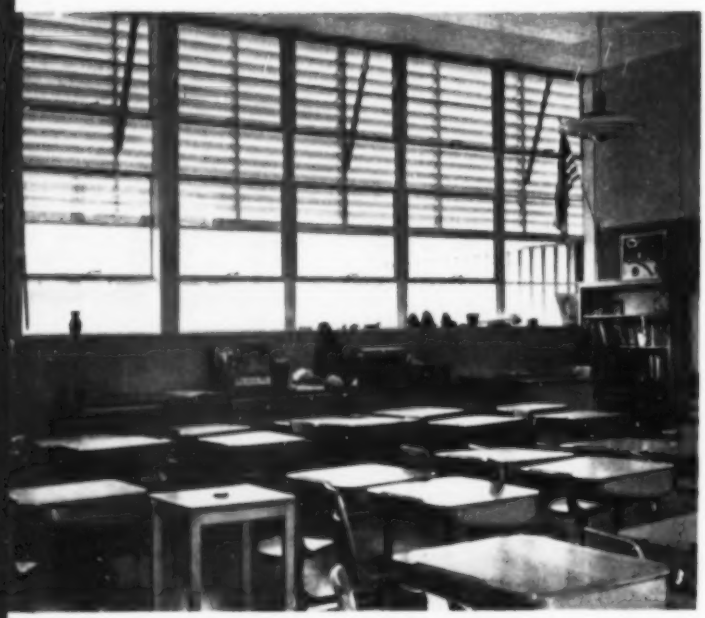
South Wall — Exterior and Interior

School: Lawrence McGee Elementary, Rivera, Calif.

Architects: Kistner, Wright and Wright, Los Angeles, Calif.

Photographer: George Johnson

Fixed horizontal aluminum louvers are installed on the eave of the corridor roof outside the southern wall, which has high window sills. The combined high sill and the louvers provide sky shielding as shown. Reflected daylight from the sunlit concrete walk supplies a considerable portion of the light in the classroom. On the north elevation, fixed horizontal louvers, together with the adjacent building, provide 360 degrees of visual comfort for most seated positions in the classroom.



North Wall — Interior and Exterior

With School Building Design

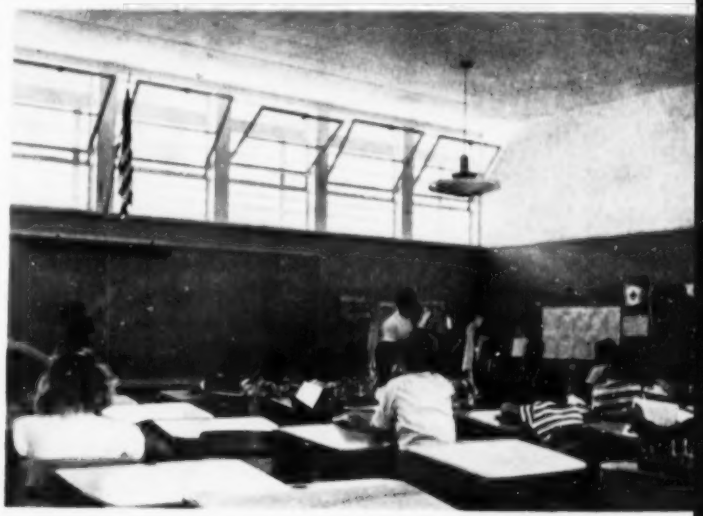
School: Rio Hondo, El Monte, Calif.

Architects: Kistner, Wright & Wright, Los Angeles, Calif.

Photographer: George Johnson

West exposure high windows are shielded from sky by fixed horizontal louvers of formed sheet aluminum set out four feet from the glass to provide good ventilation and ease of window maintenance. Interior view shows light-colored chalkboard which blends with corkboard walls. On the east exposure a solid baffle at the corridor eave combines with adjacent buildings to shield the sky from a seated position in the room. The four-foot-wide wing walls between classrooms give additional shielding, as well as making possible a greater educational use of the corridor as outdoor classroom space.

West Wall — Exterior and Interior



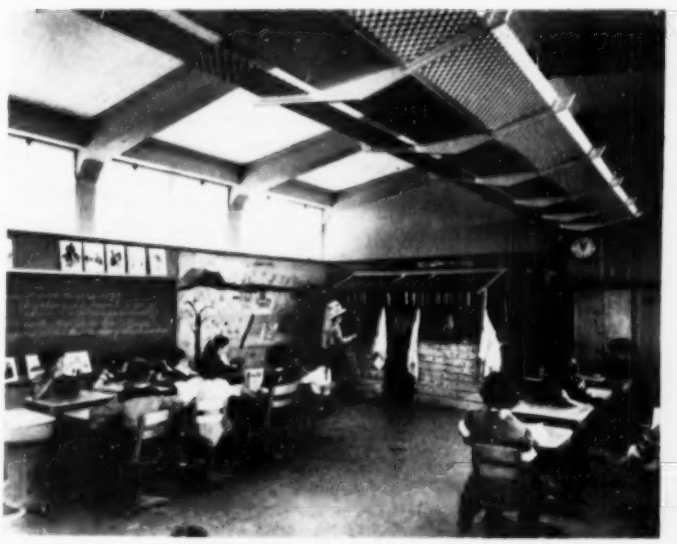
East Wall

School: George Air Base, Victorville, Calif.

Architect: H. L. Gogerty, Los Angeles, Calif.

Photographer: D. J. Higgins

The continuous element down the length of this room provides space for utility piping and continuous rows of reflector lamps directed toward the ceiling. This unusual design was developed because the precast concrete structure had no attic space. Exterior view of this school is shown on page 291.



Developing the Color Treatment for Schoolrooms

By PAUL W. SEAGERS

A DECADE OR SO ago an article on this subject would have been considered silly. In fact six years ago at a national meeting in Ohio the author created quite a stir in newspapers when he suggested "pink walls and green chalkboards." And four years ago the "professor" was branded a "crackpot" by an editor of a great midwestern newspaper. This does not mean that color has not been used in classrooms. For many decades when the white plastered walls became too dirty to tolerate, a coat of faded barnyard brown or bilious green was applied. These colors do not show dirt easily. The Illuminating Engineering Society became interested in color from the viewpoint of reflection. Dark colors or shades absorbed too much light and were, therefore, extravagant because of light waste. It was also discovered that too great brightness differences in the field of vision created problems of eye fatigue. Of course, interior decorators have always been interested in color. Psychologists and mental specialists in late years have made rather extensive studies of the effect of color upon people. Only recently has the physical and psychological impact of color been considered in the color treatment of schoolrooms.

In selecting the color for schoolrooms, consideration is usually given only to the dominant or mass color and the factors discussed below refer only to the dominant colors. However, it must be said that for good psychological color balance and to relieve monotony, accent colors must punctuate the mass color. These accent colors can be complimentary to the dominant colors and in some cases even discordant if the reflection factors are within the recommended tolerances. It is good practice to outline the accent colors when possible in white or gray. For example a bookcase sitting in front of a camelia wall would look well with a light blue interior and a white or gray exterior.

For the purpose of simplifying the procedure for selecting colors, we shall use the terms stimulating, relaxing, neutral and depressing as well as warm, cool, approaching and receding. It is recognized that these are popular rather than scientific terms and that the proper cataloging of colors under these headings is a tremendous job and only recently begun. At best many colors will be cataloged because of a majority rather than a unanimity of opinional affects. Reds, oranges and pinks are considered warm and stimulating. Blues and greens are considered for the most part cool and relaxing. Most grays will be thought of as neutral and some purples as depressing. A cool tint is the most receding and a saturated or deep-tone warm color is the most approaching. In general, tints are more receding than saturated colors and, therefore, make the room look larger.

AUTHOR: Associate Professor and School Building Consultant, School of Education, Indiana University.

Factors Considered in Selection of Colors

The geographical location of a building is the first consideration. In rather warm or hot climates, cool tints are preferred. If the color is to be subjected to intense light, a greater concentration of color pigment is required as intense light tends to wash out color.

Nearby structures or trees may overshadow or shade the room in which case lighter and, perhaps, warmer tints can be used. In some cases white or light colored structures nearby may concentrate too much light into a room and the cooler colors may be required.

The outside details of the building may be such as to prevent much natural light from entering either directly or from reflected surfaces. Then lighter, warmer colors are in order unless the room is inherently hot in which case cool tints should be used.

Orientation of the room must be considered next. If it has a north exposure, then warm tints may be in order and if it has a hot southern exposure, cool tints may well serve properly. A very sunny west exposure would suggest cool tints while an east exposure would suggest warm tints.

The size of the room must be taken into consideration. Small rooms become oppressive with heavy saturated colors. Light, cool, receding tints make the room appear larger and more livable.

The shape of the room apparently can be changed by color. A long narrow room can be "squared up" by painting the side walls a receding color and the

end walls an approaching color. Likewise, square rooms can be thrown out of square by using these same color principles. High ceiling can be "brought down" by running the off-white ceiling color down some distance on the side wall. Some people "drop" the ceilings by painting them a dark warm color. In general this is not proper for school rooms because of the excessive brightness difference and the great absorption of light by the dark ceilings. Corridors can be "shortened" by painting end walls an approaching color.

Architectural defects can be painted out or in some cases can become rather decorative when proper thought is given to the problem. It is quite common practice to paint pipes and ducts near the ceiling the same color as the ceiling and to paint pipes on walls the same as the walls. In the School of Education Reading Room, Indiana University it became necessary, because of ventilation ducts, to drop a section of the ceiling down through the middle of the room. Instead of trying to conceal this by painting the sides of this suspended portion the same as the ceiling, we featured the change by painting the sides of the suspended portion and the piers a wedgewood blue while all other walls were in peach tint. This breaks up the great expanse of the room and provides an interesting color combination.

The type of lighting fixture influences the selection of color. Indirect lighting definitely requires the lightest of ceilings. White or just off-white must be the answer. In kindergarten rooms where few close visual tasks are performed and where ceiling mounted fixtures are used, a color with a reflection factor as low as 60 per cent may be used. The kindergarten room in the Mary Raber School, Columbia City, Indiana has a southern exposure. To "cool" the room and bring the low ceiling down even closer to the little tots, a medium blue was used. The equipment and furniture was painted a great variety of colors. In fact there are twenty-two carefully selected colors, tints, shades and tones in this building. On northern exposures or rooms pocketed by wings and building projections, a plastic helmet incandescent luminaire in combination with a sunlight yellow ceiling can give a pleasing sunburst effect to an otherwise dreary room.

The color temperature of the lamps to be used greatly influences the selection of color for a classroom. The lamps which emphasize the blues and greens dictate less intensive blues and greens in the room decorations. This, of course, presumes that natural light is not sufficient for the desired tasks. Some fluorescent lamps not only are cruel to the decorations but frequently to the occupants of the room. The emphasizing of the blues and purples of the human skin is not conducive to good mental health. The color of any room must be selected under the light in which it is to be normally seen. A whole article could be written on this subject. Here we can only point out the problems involved. The desirable way is to select the lamp with the color temperatures desired for the required effect. Purchasing policies of most institutions do not allow this latitude. The next best thing is to adapt the room color to the electrical lighting.

The age of occupants should influence the selection of room colors. Children invariably prefer bright, gay, flashy colors as well as do members of the negro race. Adults prefer tones and shades or less intensive colors. Blue is a favorite with men and red with women. Thus bright colors may be used to accent the dominant colors in elementary schools while more subdued accents are used in high schools and colleges.

The type of activity may be greatly improved or retarded by color. Typing, for instance, is a subject requiring speed and accuracy. The room should be slightly exciting and stimulating. Unless excessive sunshine pours into the room, a warm tint should predominate. If the room has a north exposure then even a warmer tint should be used. A relaxing color can slow up the desired typing speed. In a room used for play purposes and where considerable freedom of action is expected, a cool tint can definitely keep down some of the boisterousness.

The general psychological effect of the room or space must be determined before any color can be selected properly. Should the overall effect be stimulating and exciting, relaxing or neutral? Naturally the principal's office, the superintendent's office, the guidance office and all general waiting rooms should be relaxing in effect. Many problems can be solved just by the psychological effect of the environment. Cool, unoppressive colors must predominate in these situations. It has often been pointed out that a cool, constant north light and a gray room were necessary for art work. To get the proper appreciation of art pieces, gray or neutral surroundings may be necessary. Likewise, it might be necessary to place blues, reds and greens in a room so the pupil can get the feel of these colors when making art subjects. Kitchens are considered hot places; cool relaxing colors should be used.

There are no general rules for the selection of colors for classrooms except that the reflection factors should generally meet those set up in the *IES Lighting Handbook*, or *ASPSL*, and that window

walls should normally be very light. However, the factors listed above must be taken into consideration and properly weighted for good selection.

There are many examples of good color practice, but perhaps the following description of some of the areas of the Mary Raber School in Columbia City, Indiana, will serve to illustrate my point. In this school, the color scheme in each area was developed specifically, with all factors considered. Selection of every color, mass or accent had a purpose — aesthetically, practically, physiologically and psychologically. The result is a "dream school."

In the Kindergarten playroom, for instance, a green was selected for two reasons. First, in a playroom, children normally run about freely; so a slightly relaxing color has a tendency to keep them from over excitement. Likewise, a relaxing color is desirable for community and auditorium uses. A fireplace on the side is painted a different shade of green. Blue could also have been used.

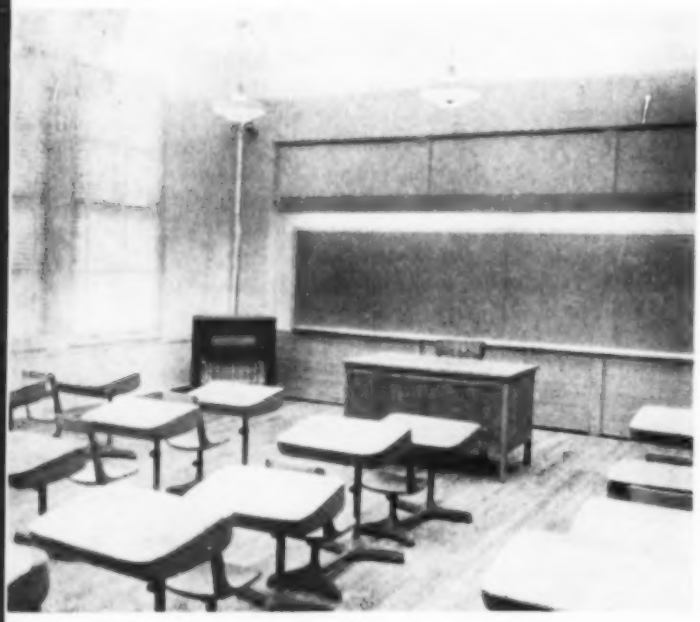
The kitchen off the playroom is in a beautiful medium palm green to "cool" the room and fit in with the decorations of the playroom.

In the main kindergarten area, the sidewalls and ceiling are in blue, the fireplace has a light yellow tint, and the floor is tan. A folding partition concealing clothes and storage area is in a neutral gray. Furniture in a great variety of colors is used for accent. In another room, sunlight yellow predominates.

In the lobby, an "inviting" atmosphere has been created with light warm tints, providing also the proper environment for the cove lighting used here.

Good judgment must always be used in selecting colors. Peach tints very seldom are wrong. Blues can be depressing, greens are difficult, browns even more difficult and yellows, especially those with a little green, should never be used alone in large room areas. Frequently it is desirable to have one wall in a complementary color or some color which will not fight with the predominant color. Some blues go well with peach tints, camelias and yellow. Some yellows go with green. A green tone can go with a peach tint. There are no known limits to the combinations. The main thing is to plan the proper psychological atmosphere giving due consideration to the physical impact of the environment especially in relation to the probable visual tasks involved. If this article has stimulated your thinking, called to your attention the complexity of color selection for classrooms, and given you a few guideposts, it has served its purpose.

School Modernization Program Includes Chalkboard Lighting



Over the past six years, the Northern California Electrical Bureau has sponsored a program for relighting older classrooms, particularly in rural schools, throughout northern and central California. Twenty-one typical older schoolrooms in this area have been repainted and relighted to demonstrate the possibilities in school modernization at a cost within reach of any school district. These model rooms have resulted in the refinishing and relighting of hundreds of older rural schools.

Recently it was felt that general lighting alone was not enough — that chalkboard areas needed additional illumination. An indirect lighting installation providing 30 ft-c on the desk top may produce only 15 on walls and chalkboards. With chalkboard reflectance of 15-20 per cent, the brightness is a small fraction of the brightness of paper on the desk top.

To correct this low chalkboard brightness, the latest two modernized classrooms — at Cordua School near Marysville and Freshwater School near Eureka — have been equipped with chalkboard lighting units. These have single T12 slimline lamps end to end in porcelain enamel reflectors, directing the light evenly over the board. The front surface of the unit is painted the same color as the wall to minimize contrast. Data supplied by John S. Walsh, Chief Illuminating Engineer, Pacific Gas & Electric Co., San Francisco. ***Photo courtesy of Fluorescent Fixtures of California.***

Visibility of School Tasks

By J. M. KETCH
C. J. ALLEN

Recognizing the existing methods of teaching which require students to work on visual tasks covering a wide range of visibility, the authors asked the principals and teachers of elementary, junior high, and high schools of one city to supply representative samples of such tasks. The relative visibility, and reflectances of ink and paper of each were measured. The range in relative visibility found in these samples was surprisingly broad and the visibilities of some tasks, even in the earlier elementary grades, were surprisingly low. It is apparent that the visibility of handwriting depends much upon the pencils and paper used and that it can be bettered by teacher emphasis. Office-reproduced materials may be good or poor according to the care and materials used. Charts are presented to help guide the selection of paper, type and spacing of better-than-average printed materials. The task and responsibility of the lighting designer are more clearly delineated by the results of this study.

THERE is considerable interest in better seeing conditions in schools by educators, eye specialists, school architects, text book publishers, manufacturers of school room finishes and equipments, and by lighting engineers. Each group has contributed materially to the steadily improving standards: by teaching about eye care, study habits, and optical correction; by studying building design, room finishes and environment; by the publication of books and maps of higher visibility; and by the development of equipments and the techniques for better utilization of natural and artificial light.

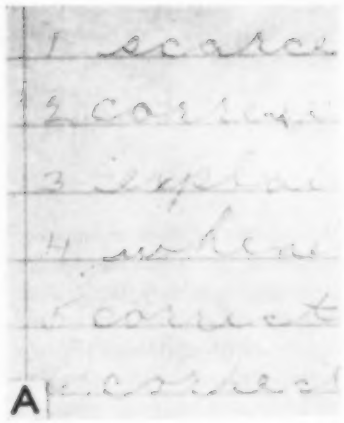
The common objective of all groups is the mental and physical development, and well being of the students. Because clear, quick, and comfortable seeing plays such an important part in this development, the kinds of visual tasks — how critical or difficult they are, and how prolonged their use — are of concern to all cooperating groups. In order that these tasks may be catalogued and classified, the authors have undertaken a study of some of the more common ones. Methods and common denominators of visibility measurement have been selected and described so that studies made of additional tasks can be compared with those reported here.

Samples of typical school visual tasks are shown in Fig. 1 arranged in their general order of difficulty as indicated by the Luckiesh-Moss visibility meter. In order to provide a scale for comparing the relative visibility of the various tasks, Bodoni book monotype of graduated point size is used. The eighteeen examples in Fig. 1 vary from a relative visibility corresponding to 3-point* Bodoni book monotype to one of 17. Twelve-point Bodoni book monotype is widely used in many books as a good balance between visibility and economy of printing. Type sizes below 8 become increasingly difficult to see, yet many examples were found where the visibility of the written work of the students was far below this size.

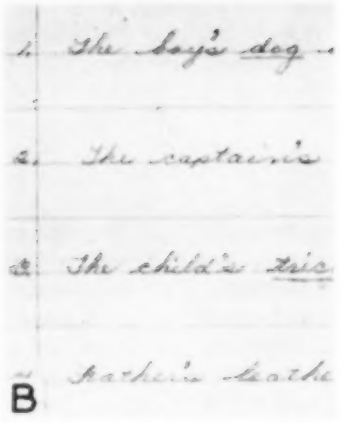
*Type size is measured in the height of the body, or base of the type metal, in points, 72 to the inch; the actual height of the type face is less and depends upon the style used.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, Sept. 8-12, 1952, Chicago, Ill.
AUTHORS: General Electric Co., Lamp Division, Cleveland, Ohio.

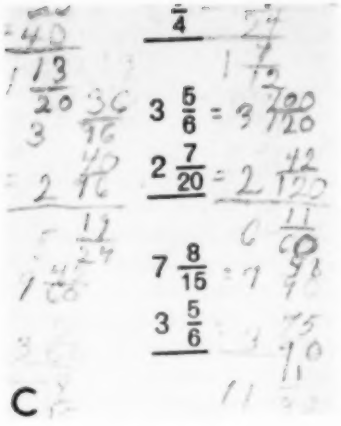
Several interesting observations may be made from Fig. 1. Examples A, J and Q show the range of visibility noted in students' pencil writing caused by the variation of the contrast of writing and paper. Some students give their work the equivalent of 17-point visibility whereas others drop down to 3-point visibility due to writing lightly with a hard pencil. Ordinary pen writing, N and R, was found to be good from a visibility standpoint, measuring better than 11-point equivalent type size in the cases shown. One example of writing with a ball point pen, H, in which the ink supply was about exhausted was equivalent to 7-point size type due to the variation in ink deposit in the formation of the individual letters. Stencil reproduction can show a considerable range of visibility. It depends upon the quality of the stencil and cushion sheet used, the uniformity and depth of the impressions, the inking and number of impressions run, and the number of times it has been stored and rerun. Examples D, L and O show the range of visibility of typical mimeograph repro-



A



B



C

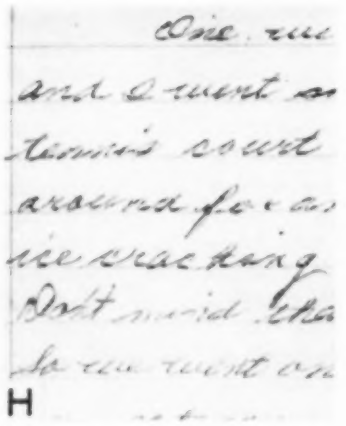
448 A FIRST COURS

TABLE III. TANGEN

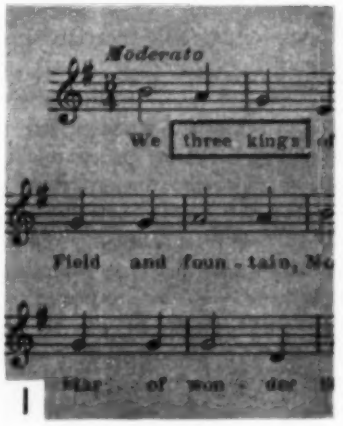
Deg.	0′	10′	20′	3
0	0.0000	0.0029	0.0058	0.0
1	0.0175	0.0204	0.0233	0.0
2	0.0349	0.0378	0.0407	0.0
3	0.0524	0.0553	0.0582	0.0
4	0.0699	0.0729	0.0758	0.0
5	0.0875	0.0904	0.0934	0.0
6	0.1051	0.1080	0.1110	0.1
7	0.1228	0.1257	0.1287	0.1
8	0.1405	0.1435	0.1465	0.1
9	0.1584	0.1614	0.1644	0.1
10	0.1763	0.1793	0.1823	0.1
11	0.1944	0.1974	0.2004	0.2
12	0.2126	0.2156	0.2186	0.2
13	0.2309	0.2339	0.2370	0.2
14	0.2493	0.2524	0.2555	0.2

G

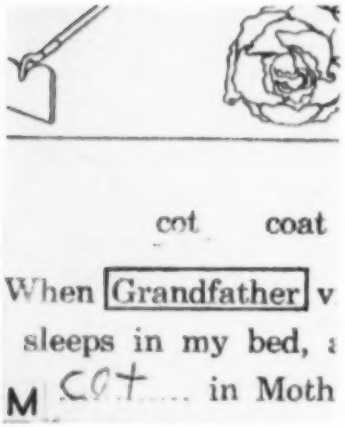
Six Point Bodoni



H

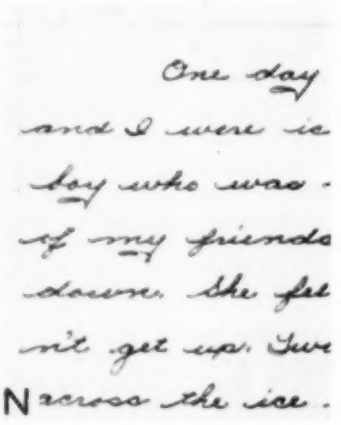
Seven Point Bodoni

I

Seven Point Bodoni



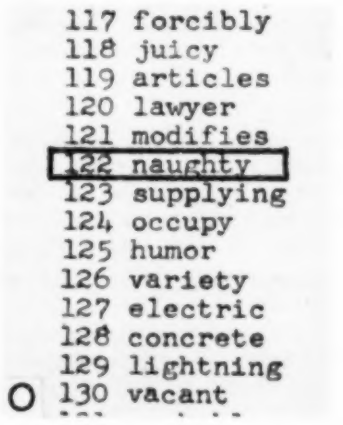
M

Ten Point Bodoni



N

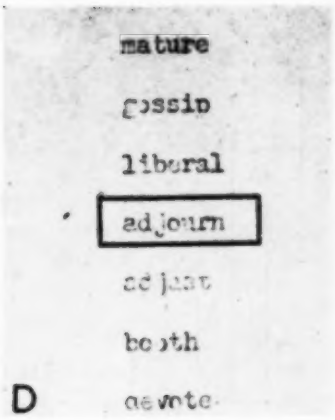
Eleven Point Bodoni



O

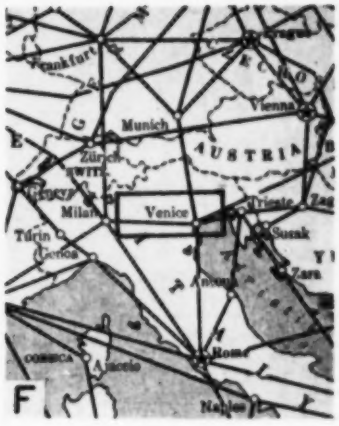
Eleven Point Bodoni

Figure 1. The examples shown on these two pages indicate the range in visibility of typical visual tasks found in schools.

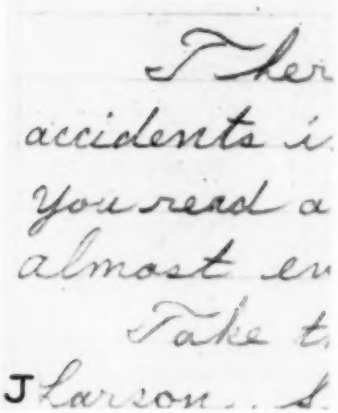


Five Point Bodoni

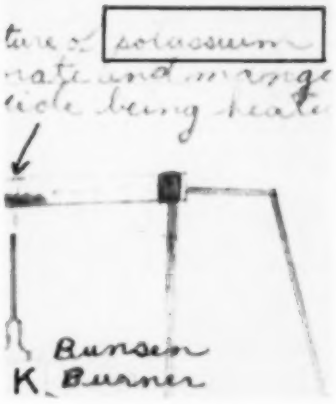
Five Point Bodoni



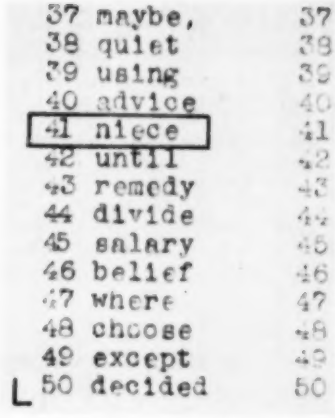
Six Point Bodoni

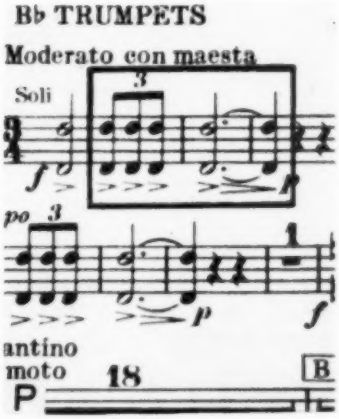


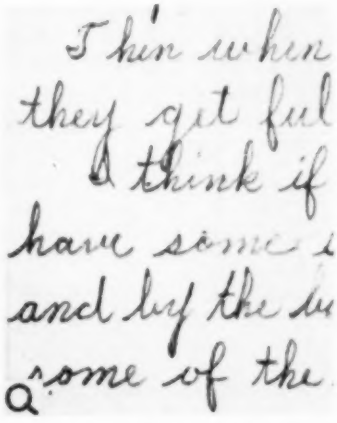
Eight Point Bodoni



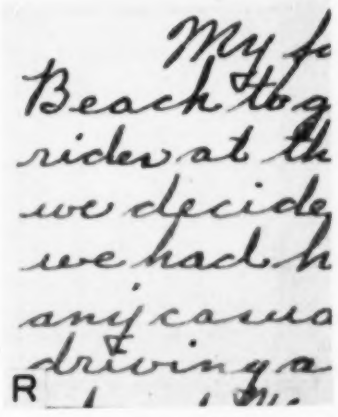
Eight Point Bodoni



Nine Point Bodoni

Eleven Point Bodoni



Thirteen Point Bodoni



Seventeen Point B

Visibility of all tasks is equivalent to the visibility of Bodoni Book Monotype shown under each example. Actual size types were used for 10, 8 and 6 point types. Other non-standard sizes were photographically produced.

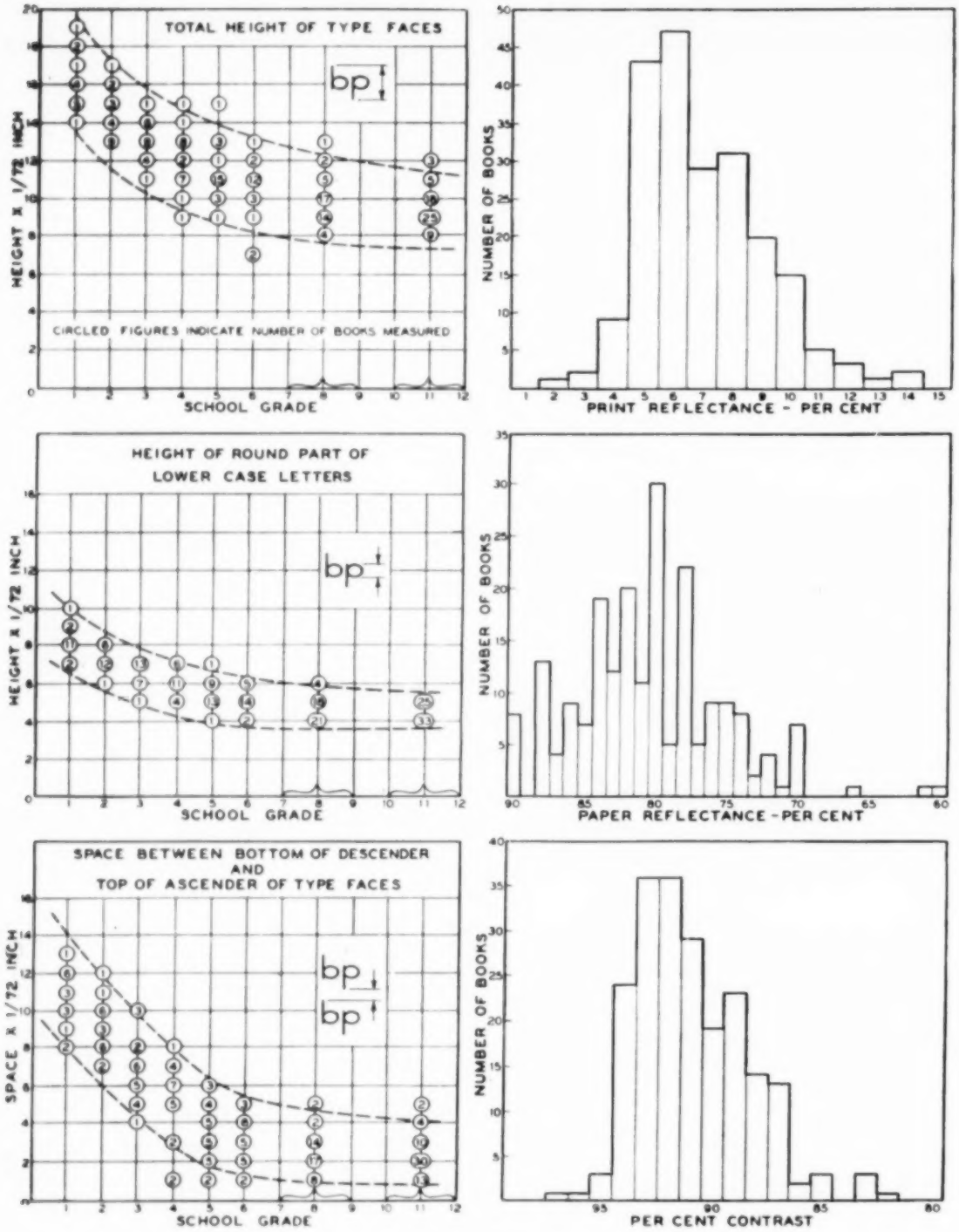


Figure 2. Variations in typography found in the actual text books used in the E. Cleveland, Ohio, public schools. This chart can be used as a guide in evaluating the print of text books for specific grades where better-than-average typography is wanted; for example, the height of the type face for a fifth grade book would be at least 12/72 of an inch, the round stroke of the lower case letters 6/72 of an inch, and the space between bottom of descenders and top of ascenders of lower case letters would be 5/72 of an inch. The ink used would not exceed 8 per cent reflectance and the paper would be at least 80 per cent reflectance, and of low gloss or specularity.

ductions. Example O illustrates good mimeographing. The other examples in Fig. 1 illustrate a number of factors which contribute to low visibility. Example B shows typical small size handwriting; example C, smudging from erasers; examples E and F, small printing on maps; example I, printing on gray paper, and example M, printing with gray ink.

Some of the visual tasks can be considered improved; others less so, or not at all. For the latter, improvement in seeing must come from a reduction of negative factors — glare, reflected glare, high brightness contrast — and increases in positive factors — illumination, etc. Maps are good examples of tasks where the size of the printing is inherently limited. An example where improvements can be made by proper supervision is in pencil writing. As an experiment, duplicate spelling lessons were written by a student who writes with a good pressure when using a No. 1, soft, a No. 2, medium soft, and a No. 3, medium hard pencil on white paper. The equivalent point-size visibility dropped from 15 to 11 to 7 as a result of the grade of pencil used. When the child wrote the same spelling lesson on yellow paper with the same three pencils the comparable point sizes lowered to 13, 8, and 3 because of the lower reflectance of the paper. While yellow paper is cheaper than white paper, and a No. 3 pencil will last longer than a No. 2 or No. 1 pencil, their use may be poor economy in the light of the lower visibility of the work for both students and teachers who must correct it.

Reading occupies a large portion of the students' learning years. The number of books which must be read from the time they enter the primary grades until they graduate from high school will make a single stack about 18 feet high. Of the books submitted for this study of typography about three-fourths were published during the last decade. Fig. 2 shows the total height of the letter faces, the height of the round part of lower case letters, the space between lines of type, and reflectances of the ink and paper. These curves indicate a gradual decrease in height of the type faces, and in the space between lines in the books for the students as they progress from the period when they are learning to read, to the period when they are reading to learn. The variation in the heights of the type faces found in books for each grade is shown also. Although the actual height of type faces is not defined in points (1/72 of an inch) the measurements are given here in seventy-seconds of an inch for comparison purposes.

The height of the type faces varied from 18/72 of an inch for the largest type used in first grade books, to 8/72 of an inch, the smallest type generally found in high school books. Most of the variation in type face height is accounted for by the ascending and descending part of the letters; there is a substantially smaller variation in the heights of the round part of the individuals letters. The space between lines of type in the lower grades is as much as six times that found in books used in junior and senior high school. In the lower grades this interlinear spacing is as much as 12/72 of an inch; in the upper grades it decreases to 2/72 of an inch. This variation is a function of the size and style of type used and whether the type is set solid or leaded.

The study of paper shows that reflectances as high as 90 per cent are possible, but among the visual tasks surveyed, book papers with reflectances as low as 60 per cent were found. The task and background reflectances were measured with a micro-reflectometer with the incident light at 45 degrees with the paper. Ink reflectances varied four to one, ranging from good black ink of 3 per cent reflectance to grayish inks of 13 per cent reflectance. The average per cent contrast (paper reflectance minus ink reflectance divided by the paper reflectance) was about 90. The charts, Fig. 2, show the statistical spread of each of the factors measured.

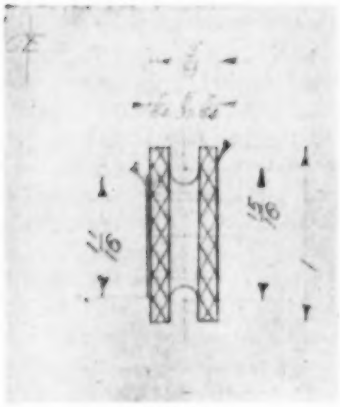
There are both practical and economic reasons for some reduction in type sizes as the amount of text per book increases in upper grade books although for best task visibility the larger types, set open or leaded, are preferred. There is less reason for poor contrast between the ink and paper of printed texts. It is the obligation of both producers and buyers of printed school materials to keep the combination of variables at a point well above the statistical average shown for a given school grade.

Conclusions

Three general task groupings and conclusions are suggested by this survey.

There are many visual tasks which are inherently difficult because of the size of the detail to be seen, its lack of contrast with its background, or because of disturbing reflections. Although modifications can be made which will improve the visibility of some of these, it is evident that most of the help must come from more suitable lighting and visual environment. Tasks of this group are some which need further study preferably coordinated by the I.E.S. School Lighting Committee.

2. In regard to printed materials, the survey indicates a commendable effort by publishers to keep the visibility of their materials as high as possible consistent with the type size and leading which are traditionally considered a function of

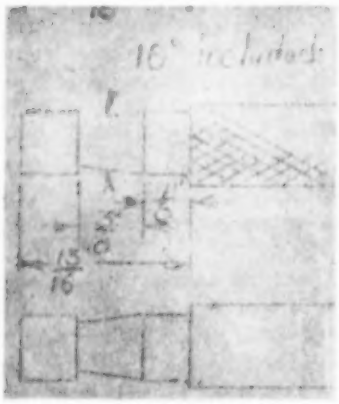


Mechanical drawings require accuracy and often small lettering. Construction lines are usually faint.

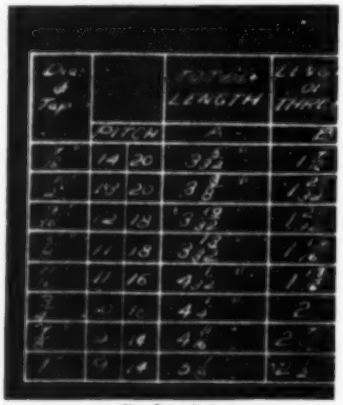
Drafting scales: Top — white face; bottom — yellow boxwood.

Ten Point Bod

Preliminary Biology drawings with very hard sharp pencils capture small detail but have low visibility.

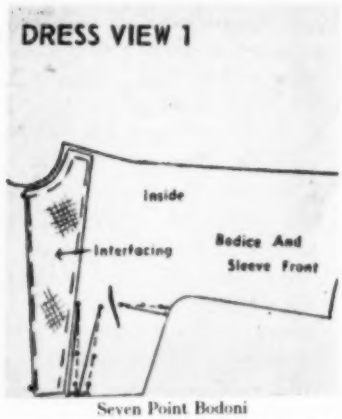


Hectograph or liquid duplicator gives low visibility if care is not exercised when reproducing.



Five Point Bodoni

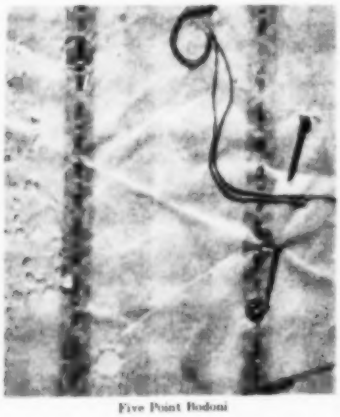
Good blueprinting, but small numbers result in low visibility.



Seven Point Bodoni

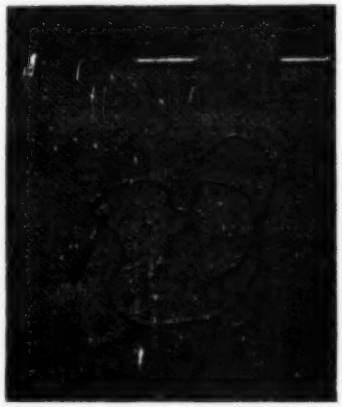
Gray ink on grayed paper plus small lettering results in low visibility on instruction sheets.

Sewing with black thread on black cloth is a classic example of poor visibility.



Five Point Bodoni

On light materials to find and mark tailor tacks in patterns is a very difficult visual task.



Fine hand tailoring is a difficult school task. Local and general lighting are both needed.

Figure 3. Examples of a few of the specialized visual problems found in high schools. Many of these are inherently difficult and visibility improvements are possible chiefly by use of better lighting and more favorable visual environment.

the amount of text to be printed. There was a fairly wide spread of type sizes found in the materials for some of the school grades and also a few which were of low contrast. It will be possible for both publishers and purchasers of printed materials to use these curves showing the statistical spread of type size, and ink and paper contrast, to insure better-than-average materials.

3. Many of the written lessons of the students and instruction sheets produced by office duplicators were low in visibility. These put a burden on both the students and teachers. An improvement in handwritten material can best be made by the teacher who might stress the need for larger writing by some pupils and more pencil pressure by others. The teacher can also help by suggesting softer, blacker, pencils and paper of better reflectance. Materials reproduced by office duplicator machines can be of good visibility if those who produce them use care in preparing the original, and in running duplicates.

Acknowledgments

The cooperation of the principals and teachers of Caledonia Elementary School, W. H. Kirk Junior High School and Shaw High School, East Cleveland, Ohio, is greatly appreciated. They assembled and provided the examples of typical school tasks which made these studies possible.

Acknowledgment is made to Ginn and Company for permission to reproduce Figs. 1-E and 1-F from *Nations Overseas* by Atwood and Thomas, and to B. H. Sanborn and Company for permission to reproduce Fig. 1-G from *First Course in Algebra* by Mallory.

DISCUSSION

LEONARD V. JAMES*: A reader of this paper might wonder why no information is given about the illumination level on the tasks at the time their visibilities were determined, the brightnesses due to this illumination certainly having an important influence on the visibility. No doubt the authors assumed it would be understood that the visibility here given is relative to a type standard and that, the same illumination being applied to the sample and to the standard, no such record was necessary.

I do feel, however, that by leaving the results in terms of sizes of type of the same order of visibility the authors missed an opportunity to clarify their findings. The significance of the standards may be as little comprehended by most of us as is that of the samples themselves. It would have helped to have taken one more step and have reported the relative footcandles in each case, comparable surrounds assumed, to equalize the visibilities of the various type sizes and for that matter of the samples.

Certainly, the final benefit in knowing the relative visibilities of tasks is so that we can correct or rather equalize these visibilities. To do this by varying the illumination levels, as suggested, not only reduces the results to an understandable basis but also would at least connote the cost of doing so. Without carefully checking the results, I am of the opinion that the range of footcandles so determined would have been much greater and much more impressive than the numerical range in type size.

It is to be regretted that the authors limited their specific analysis to so few tasks. The study should soon be extended to include typical or extreme chalkboard and tackboard or map tasks and to many other tasks encountered in the drawing and art rooms, in the shops and in typing, sewing and culinary art rooms. Such a comprehensive study would emphasize still further the problems confronting those who would plan tasks and lighting which are at once most practical and still helpful to those who must work at these tasks.

Would it be too much to hope that the authors will continue this good work and that they or others will extend it to other fields, particularly in the office, in the home and in industry, and that the results be reported in serial form in ILLUMINATING ENGINEERING, later to be accumulated perhaps as a valuable aid to all concerned?

R. L. BIESELE, JR*: This paper makes one wonder why the information it contains was not considered essential to intelligent specification of school lighting long ago. The fact that a considerable number of very difficult visual tasks exists in our classrooms has been suspected by many for some time, and the paper should have a salutary effect in correcting or improving some of the most difficult. It is to be hoped that further investigation will be carried out by the authors or perhaps by others more directly associated with the field of education. Such information will provide a surer basis for our Society's recommendations for school and office lighting.

JAMES M. KETCH and CARL J. ALLEN**: Answering Mr. James' comment that no information is given about the illumination level on the tasks at the time their visibilities were determined, it actually makes no difference in the *relative* visibilities of unknown tasks and reference types, as long as the observers, the illumination and the surround are identical, and constant.

These tasks were all measured under controlled laboratory conditions which made it possible to eliminate variables and to correct personal variations of observers' eyes, or drift during a test series, to that of an average eye. Observers working with an illumination of 20 footcandles read alternately the visibility of the unknown tasks and that of the known 8 pt type reference. Although our findings have been reported in the simplest terms and in equivalents which can be duplicated by others, the actual work was done with laboratory precision using the best known techniques and instruments designed for visibility researches.

The interpretation of these findings in terms of footcandles necessary for equal visibility for all tasks reported, would, in our opinion, confuse the main objective without extending the information on this subject already published.

The tasks selected for our first investigation were those which could be measured under controlled laboratory conditions. It is hoped that later other, and equally important, tasks can be included which must be measured on location.

*Illuminating Engineering Consultant, La Grange, Illinois.

*Toff Corporation, Dallas, Texas.
**Authors.

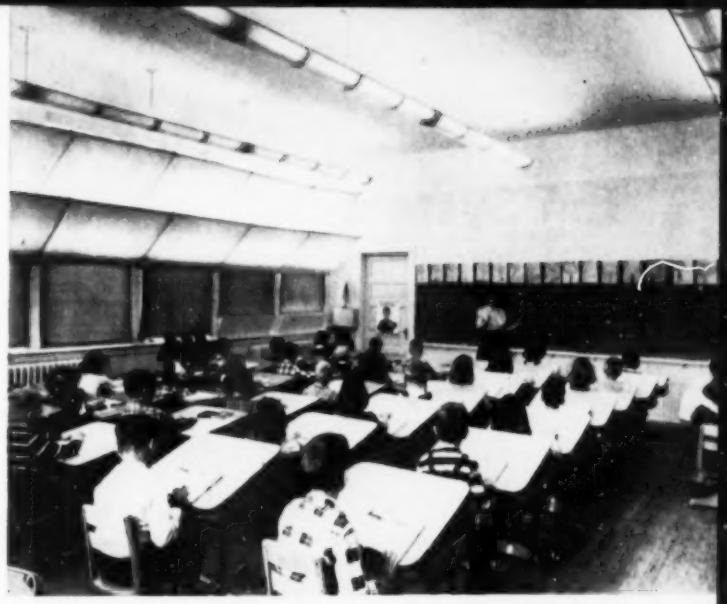
Often in schools in small communities the usual desk-type classrooms have been relighted, but other important areas have been neglected because it is not usually realized by school officials that the seeing job in such areas as home economics rooms, manual training, etc., can be even more difficult than in the usual classroom. But this illustration shows a relighted home economics rooms in a small community high school in Maize, Kansas, where average level is 40 ft-c from two-lamp 40-watt T12 fluorescent luminaires, and high reflectance surfaces. Photo and data submitted by Frank H. Armstead, Kansas Gas and Electric Co., Wichita, Kansas.

Small Budget Rural Schools Want Good School Lighting

Small town schools are frequently far ahead of their city cousins in providing good visual environment in classrooms, in spite of stringent budget restrictions. On this and the facing page are shown a few of the hundreds of small community schools which have been relighted to I.E.S. standards or, sometimes, even better.

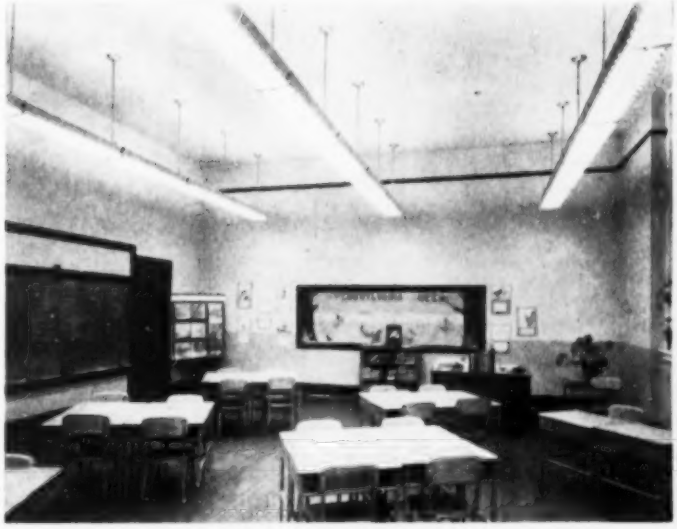
A basement room converted to a classroom in Harrisburg, Illinois, uses flush-mounted 425-ma slimline units, two-lamp, 75-watt, on the low (8 ft 8 inch) ceiling, in 16-ft sections on 9-ft centers. Bullet type units provide added illumination on the chalkboards. Ceiling and walls were painted white to a point below the pipes, blending these obstructions into the ceiling and making them less noticeable. Photo and data submitted by Edward O. Humphrey, Lighting Engineer for Central Illinois Public Service Co.

Every possible lighting defect has been corrected in this relatively old rural school in Hampton Township, Pennsylvania. Note the two continuous sections of fiber glass cloth diffusers placed at a 45° pitch at the high narrow windows; light yellow sidewalls and blonde furniture; three continuous rows of two-lamp 40-watt fluorescent luminous-indirect luminaires. Photo and data submitted by A. G. Caplan, Duquesne Power Co., Pittsburgh, Pa.



First graders at this consolidated school near Trooper, Pennsylvania, have 35 ft-c of comfortable illumination from concentric ring incandescent luminaires using 500-watt silver bowl lamps. Spacing is 12 ft by 8 ft and suspension is 30 inches on the 10-ft ceiling. All surfaces are of high reflectance. Photo and data submitted by George Anderson, Jr., Philadelphia Electric Co.

Proper suspension of luminaires at 9 ft 10 inches from the floor was required for this high-ceiling (12 ft) classroom in Black Horse, Pa. Spacing of the two-lamp shielded commercial luminaires is 7 ft 9 inches; illumination level is 40 ft-c maintained. Submitted by George Anderson, Jr., Philadelphia Electric Co.

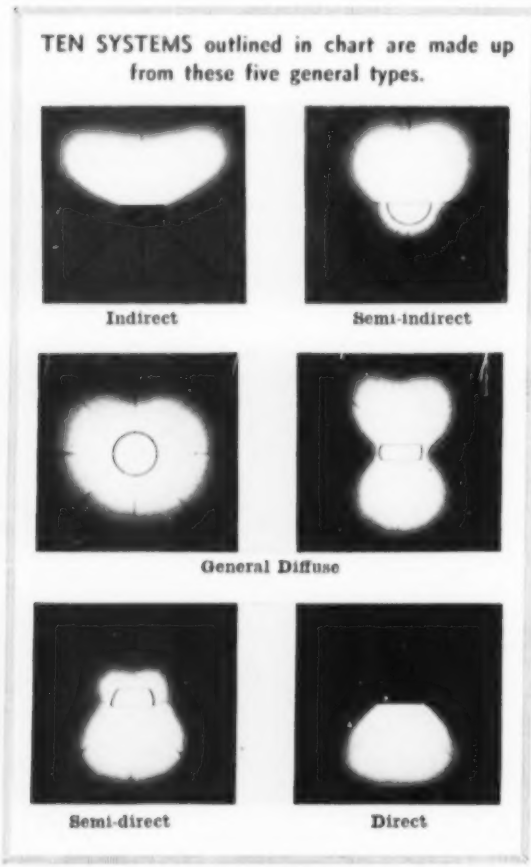


Meeting Recommended Practice . . . Ten Systems

By G. G. GILLEARD

SCHOOL LIGHTING which meets the ASPSL recommended practice is the aim of architects and school boards the country across. At the same time, economics is also a serious factor. In the analysis shown in table opposite, ten different lighting systems, and the economics involved for them, are presented. With each type, the number of luminaires required to provide 30 footcandles (recommended illumination level) is shown at the left of the drawing. Where both 48" and 96" units are given the number of units is based upon using 48" units. The calculated average maintained illumination for the given room size is indicated on the right of the drawing. The ten systems selected for comparison all have a glare factor below 15, or a comfort rating in line with ASPSL. The lighting source used in each system is shown in column two. All systems use lamps that do not require starters and light within a fraction of a second.

AUTHOR: Curtis Lighting Inc., Chicago, Ill.



Cost figures shown in columns 3, 4, 5, and 6 are based up on the cost to the school per square foot of floor space. In the analysis of each lighting system the same cost basis was used in each case to determine the school's cost from published manufacturers' prices. In a like manner the cost of lamps to the schools was based upon the same discount schedule for each type of lamp.

The total capital cost of the lighting system is given in the third column. This includes the cost of the lighting equipment installed, complete with lamps. The cost of wiring including the required number of circuits, outlets and switches in the room is included.

The cost of lamps for 6000 burning hours is given in column four. The lamp life used for all lamps is 80 per cent of the published rated average life for the lamp. The number of burning hours per year will vary with the different parts of the country but in most cases the 6000 hours would cover from 6 to 10 years.

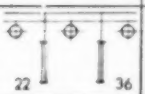
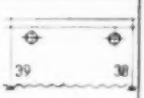
The operating cost in each lighting system may be compared by studying figures in column five. The upper figure is the energy consumed in watts per square foot. The lower figure is the cost of this energy for 6000 hours at a rate of $.03 per kilowatt hour.

The total cost of each lighting system for the first 6000 hours is given in column six. This is the combined capital cost and the operating cost given in columns three and five. If it is desired to extend the comparison to 12,000 hours the figure in column 6 should be added to the figures from column four and five.

The various systems have their advantages and disadvantages in the amount of maintenance required to maintain the desired level of illumination. The next to the last column in the chart gives the number of times that the lamps must be changed and the minimum number of times the equipment should be cleaned during the 6000-hour period. Based upon the maintenance required the various systems have been given an arbitrary rating of from I to IV.

Ten Systems for Lighting in Classrooms — Economics

All these systems provide minimum of 30 footcandles and glare factor less than 15. Room used for comparison—23′x32′x11′ with 75% ceiling, 35% walls, 15% floor.

No. Units	(1) No. & Type Lighting Equip.	ft. c.	(2) Lamps (No Starters Req'd.)	All Costs Are Per Square Foot: (3) Total Cost (1 & 2) Installed	-(4) Cost Lamps 6000 Hrs.	(5) Watt/Sq. Ft. Cost 6000 Hrs. $0.03 KW Hr.	Total (3) Plus (5) Operating Cost 6000 Hrs.	Relamping & Maintenance	Refl'd. Glare & Shadows
	Indirect Type (90-100% Up)								
9		34	500 Watt Silver Bowl Lamps	$0.45	$0.10	6.1 $1.10	$1.55	7-Lamps (II)	A
21		35	48"-40W-T12 Rapid Start 96"-74W-T12 Slimline	$1.25	$0.05	2.7 $0.48	$1.73	1-Lamp 14 Cleanings (IV)	A
	Semi-Indirect Type (60-90% Up)								
9		30	500 Watt Inside Frosted Lamps	$0.40	$0.06	6.1 $1.10	$1.50	7-Lamps 14 Cleanings (IV)	B
21		35	48"-40W-T12 Rapid Start 96"-74W-T12 Slimline	$0.90	$0.05	2.7 $0.48	$1.38	1-Lamp 14 Cleanings (IV)	A
	General Diffuse Type (40-60% Up) (60-40% Down) Semi-Direct Type (90-60% Down)								
14		32	48"-40W-T12 Rapid Start 96"-74W Slimline	$0.70	$0.03	1.9 $0.32	$1.02	1-Lamp 7 Cleanings (II)	C
16		40	60"-40W-T17 Low Brightness	$1.00	$0.10	2.2 $0.40	$1.40	1.25 Lamps 7 Cleanings (II)	B
	Direct Type (100-90% Down)								
24		35	60"-40W-T17 Low Brightness	$1.40	$0.07	1.7 $0.30	$1.70	1.25 Lamps 7 Cleanings (II)	B
16		35	60"-40W-T17 Low Brightness	$1.00	$0.10	2.2 $0.40	$1.40	1.25 Lamps 7 Cleanings (II)	C
22		36	96"-40W-T12 Slimline Low Brightness	$1.15	$0.07	1.6 $0.28	$1.43	1-Lamp 7 Cleanings (I)	B
39		38	96"-40W-T12 & 72" Low	$2.50 $4.50	$0.12	2.6 $0.46	$2.96 $4.96	1-Lamp 14 Cleanings (IV)	A

The low glare factor assures comfort from direct glare, but it is also desirable to have a minimum of reflected glare and a type of distribution that minimizes shadows. The last column in the chart is again an arbitrary alphabetical rating of the various systems with regard to these factors.

The information in the chart in dollars and cents was calculated using new construction and with given labor costs. It is understood that the cost given will vary from one location to another and depending upon various construction details. Although the individual job cost figures may vary the relative position of one system as compared to another will remain the same. The cost figures given in the chart may be reduced to a ratio or percentage in making comparisons. The same ratios or percentages will then hold true under different local conditions.

Luminous Indirect

High level (50 ft-c) illumination with comfortable brightnesses is a feature of this Clairton, Pa., elementary school. Luminaires are luminous-indirect plastic using two 40-watt lamps each, and are suspended in three continuous rows. All surfaces are light colored.

Several Techniques In School Lighting Systems

Semi-Indirect

Six continuous rows, crosswise of the room, suspended on one-foot stems, provide 45-50 ft-c. Luminaires use two-lamp 40-watt low brightness lamps and have 40° crosswise shielding. No brightness values are in excess of 150 footlamberts.

Recessed

Rectangles in three-lamp 40-watt fluorescent troffers provide 45 ft-c in service at St. Michael's High School, Pittsburgh, Pa. Upper three panes in windows are of diffused glass fenestration; lower two in clear glass. Note high reflectance floor and all light surfaces.

Photos and data submitted by A. G. Caplan, Pittsburgh Section, I.E.S.

Meeting Lighting Quality Requirements In School Classrooms

By JOHN J. NEIDHART

TO PROVIDE light for seeing in school classrooms, two major requirements must be satisfied. First, an adequate *quantity* of light for quick, easy, accurate seeing must be provided. Secondly, the light must be of proper *quality* to insure maximum clarity of the visual task, efficient functioning of the eyes and the visual mechanism, and a pleasant, comfortable visual environment.

Since providing an adequate amount of light is a relatively simple problem, it does not seem necessary to discuss this requirement further. The quality factors, however, are quite complex and are the subject of many studies and considerable discussion by I.E.S. technical committees today. This article shall, therefore, discuss some of these quality factors and how they can be properly dealt with when planning lighting for schools.

What has been rather loosely referred to as "quality factors" includes direct and reflected glare, brightness differences in the visual field, diffusion—or in the negative sense—shadows, and uniformity of illumination. Of these factors, glare and brightness differences merit the most attention and shall be considered below.

Luminaire Brightness

The I.E.S. Committee on School Lighting and the American Standards Association took one of the pioneering steps in establishing quality standards for minimizing direct and reflected glare when they published in the 1948 American Standard Practice for School Lighting recommended limiting brightnesses for luminaires to be used in school classrooms. This was a bold step, because very little information was available upon which to base the recommendations, but they were surprisingly successful. The problem of satisfying these recommendations was placed squarely before the fixture designers, and specifying agencies were given something definite to call for in specifications. The Standard Practice aroused some worthwhile arguments and started other people and committees working on the problem. Any set of recommendations this basic and important deserves a rather thorough coverage in an article on meeting lighting quality requirements in school classrooms. The basic luminaire recommendation is, therefore, repeated in Table I. It should be noted further that a qualifying paragraph in the ASPSL explains that these brightnesses may be approximately doubled if light finishes are used on room surfaces or furniture and the bright areas of the luminaire are small.

TABLE I.—Recommended Brightness Limits for Luminaires.

Zone (0° is directly beneath luminaire)	Recommended Brightness Limits in Footlamberts*
60° - 90°	225
45° - 60°	450
0° - 45°	1000

*Comparative values in candles per square inch, respectively, 0.5, 1.0, 2.0.

At the time the ASPSL was published in 1948, the most popular equipment used to light school classrooms was direct-indirect fluorescent luminaires having louver shielding of approximately 30° crosswise and 25° endwise. As might be expected, such luminaires fail to conform with even the doubled brightness limitations shown in Table I. It seemed to many that the 45° zonal demarcation in Table I necessitated louvers providing 45° crosswise and endwise shielding of the lamps. This philosophy led to the specification and development of direct-indirect luminaires having 45° louvers. In general, such luminaires more than satisfied the doubled Table I brightnesses, but the improvement was accompanied by a material reduction in efficiency, and the tighter shielding frequently increased the luminaire cost considerably. The logical solution seemed to be a louver designed to more exactly satisfy the recommended brightness limitations, and such a louver was soon introduced.[1] This louver, which was designed in the photometric laboratory by "cut and try" techniques and has no fixed shielding angles, could be produced much more economically than a 45° louver for the same luminaire, and the luminaire efficiency with this

AUTHOR: Westinghouse Electric Corp., Cleveland, Ohio.

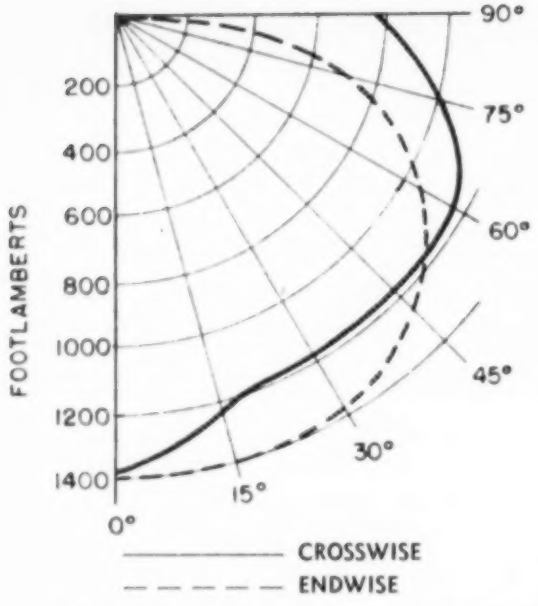


Figure 1. Average brightness curves for a 2-lamp 40-watt unshielded fluorescent luminaire.

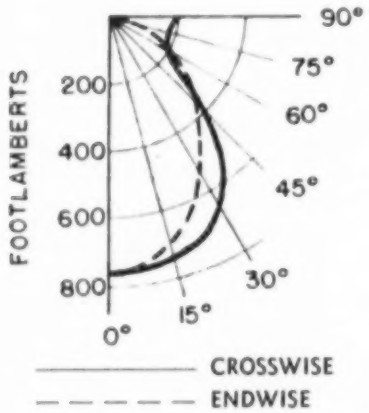


Figure 2. Average brightness curves for a 2-lamp 40-watt direct-indirect fluorescent luminaire with X° louver designed to satisfy ASPSL brightness limitations.

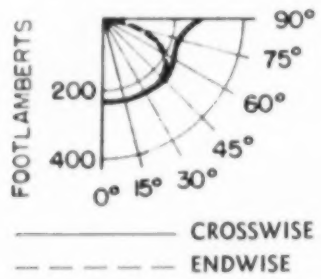


Figure 3. Average brightness curves for a 2-lamp 40-watt semi-indirect fluorescent luminaire with translucent plastic bottom and side panels.

louver was appreciably improved over the efficiency with the 45° louver.

None of the luminaires discussed thus far could satisfy the actual Table I brightnesses; the doubled values were used as the criteria, and it should be noted that such luminaires are considered satisfactory only when they are used in suitable environments. Since the rated brightness of 40-watt bipin and T-12, 425 ma slimline lamps, for instance, is nearly 2000 footlamberts, the Table I brightnesses can be obtained only by completely shielding the lamps by a low transmission medium throughout the 0-90° zone. In my opinion, semi-indirect fluorescent luminaires designed to satisfy the A.S.A. recommendations represent one of the most satisfactory and comfortable methods of lighting school classrooms. More widespread acceptance of such luminaires is probably prevented only by their higher cost, lower utilization coefficients, and the more frequent cleaning required to keep them operating at a reasonable efficiency. Properly designed and shielded indirect incandescent luminaires also satisfy the Table I brightnesses. Their installation requires a smaller initial investment, but a higher operating cost and their necessarily higher total wattage may create a heat problem in certain climates. It should be recognized, however, that the improved quality of light resulting with semi-indirect or indirect illumination more than justifies added costs, if any. Such lighting minimizes both direct and reflected glare and improves diffusion and uniformity of illumination.

The recommended brightnesses given in Table I are maximum brightnesses for each zone. That is, they refer to the brightest square inch that can be found in each zone by exploration in the laboratory with a brightness measuring instrument. However, except when it is looking directly at the luminaire or when the bright area greatly exceeds other adjacent areas of the luminaire the eye does not pick out and respond to these small brightest areas. It sees instead the large mass of brightness overhead as presented by the entire luminaire. Thus, it sees the *average* brightness of the luminaire. The average brightness at any angle is merely the candlepower at that angle divided by the projected luminous area of the luminaire. It can be readily computed from candlepower distribution data and the physical dimensions of the luminaire and plotted on polar coordinate paper to form curves similar to candlepower distribution curves. Such curves of average brightness graphically show brightness characteristics of luminaires as they will affect seeing comfort. For example, a comparison of the average brightness data shown in Figs. 1 and 2

quickly and forcibly demonstrates the superior brightness control provided by the luminaire whose curve is represented by Fig. 2. Still greater comfort can be expected from an installation of luminaires having the brightness characteristics shown by Fig. 3; in this case it is evident that the brightness is well controlled throughout both the direct and reflected glare zones.

The many attributes of average brightness data ensure its acceptance as the primary means of specifying and reporting luminaire brightness in the near future. Maximum brightness will probably continue to be used only as a safeguard against small areas of extremely high brightness that might prove distracting or uncomfortable when viewed directly.

Brightness Ratios

Luminaire brightness is not the only factor that must be considered in designing for seeing comfort. Proper brightness relationships between all parts of the visual environment must be maintained so that the eye will not be forced to readapt itself to materially different brightnesses as it looks about the room. To prevent unbalanced brightness distributions in school classrooms, the ASPSL includes a table of brightness ratios which should not be exceeded (Table II). Although it is now possible for lighting equipment manufacturers to publish coefficients of utilization that would permit the simple calculation of average wall and ceiling brightnesses for any installation,[2] such data are not yet available. An expedient is therefore employed whereby the furniture and room surface reflectances are given that should ensure good brightness relationships if a satisfactory lighting installation is made. Fig. 4 shows these recommended reflectances as they are given in the ASPSL.

TABLE II.—Recommendations for Limits of Brightness Ratios in Schoolrooms.

(Rooms used by faculty or pupils for educational purposes.)

	Ratio
a. Between the "central visual field" (the seeing task) and immediately adjacent surfaces, such as between task and desk top, with the task the brighter surface.*	1 to 1/3
b. Between the "central visual field" (task) and the more remote darker surfaces in the "surrounding visual field," such as between task and floor.**	1 to 1/10
c. Between the "central visual field" (task) and the more remote brighter surfaces in the "surrounding visual field," such as between task and ceiling.**	1 to 10
d. Between luminaires or windows and surfaces adjacent to them in the visual fields	20 to 1

*Chalkboard and some art and shop tasks are illustrations of cases where the reverse ratio of 1 to 3 may apply.

**These ratios apply for areas of appreciable visual size as measured by the solid visual angle subtended at the eye. Luminous areas on luminaires are generally small in size in this respect. For the brightness limitations of luminaires, see Table I and (d) in Table II.

Chalkboard Visibility

One of these reflectances, that of the chalkboard, merits further discussion, for it affects the visibility of one of the more critical classroom seeing tasks. Visibility, or the ease with which a seeing task may be accurately discerned, is greatly influenced by the brightness contrast of the elements forming the task. In the case of a chalkboard, the visibility of writing on it is dependent upon the difference between the brightness of the chalk marks and the brightness of the chalkboard. To determine the effect of various combinations of chalk or crayon and different available chalkboard materials on visibility, a group of representative samples of these materials was obtained and a study was made.[3] Their characteristics, including measured reflectance data for clean and chalked boards and for chalk marks on the boards, are tabulated in Table III. From the reflectance data, per

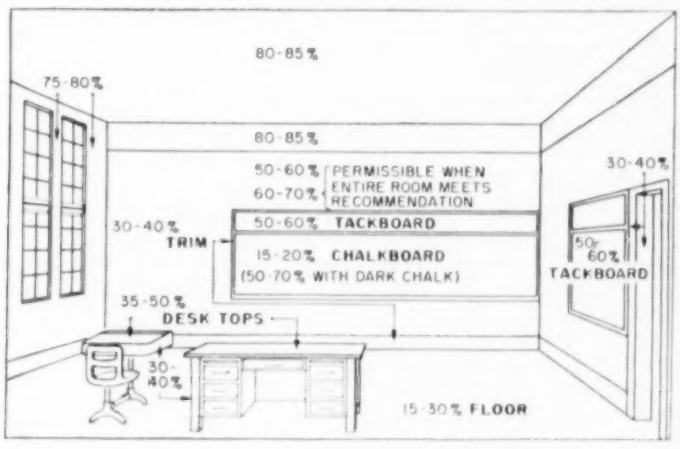


Figure 4. Reflection factors desirable for schoolroom surfaces.

TABLE III.—Characteristics of Chalkboard Materials.

No	Description	Color	Approximate Reflectance			Computed Contrast	
			Clean Board	Chalked Board	Chalk or Crayon Mark	Clean	Chalked
1	Coated Pulp Board	Green	.18	.25	.51*	65%	51%
2	Coated Pulp Board	Green	.09	.19	.51*	82%	63%
3	Coated Pulp Board	Black	.07	.15	.58*	88%	74%
4	A Chalkboard Coating	Green	.10	.17	.56*	82%	70%
5	Coated Hard Board	Green	.20	.25	.56*	64%	55%
6	Coated Heat Tempered Glass	Green	.15	.19	.53*	72%	64%
7	Coated Heat Tempered Glass	Ivory	.59	.48	.14**	76%	71%
8	Enameled Masonite	Ivory	.60	—	.16†	73%	—

*White Chalk **Black Chalk †Black Crayon.

cent contrast was computed to obtain an indication of the relative visibility of each combination.

Although contrast is an indication of visibility, a more direct check is to measure the visibility of a teacher's normal writing as it appears in an actual classroom. A teacher was, therefore, asked to write several lines in her normal style on clean chalkboard samples No. 1 (light green) and No. 4 (dark green), which were considered as being representative of the currently popular light and dark green boards. The results of visibility meter measurements of these samples in a typical classroom are shown in Fig. 5. By means of conversion curves the data as taken have been converted to illumination levels of 15, 30, and 60 footcandles — a range representing minimum to better than current practice values. The 30-footcandle center value is the recommended minimum for chalkboards in the American Standard Practice, but this requirement is often ignored in lighting designs. Installations are usually designed to maintain an average illumination level of 30 footcandles on the desks, and the illumination on the chalkboard is only about half the horizontal level unless additional chalkboard lighting is provided.

Among the many conclusions that may be drawn from an examination of Fig. 5, the following are most significant.

(1) Chalkboard visibility, even at high illumination levels, is well below the visibility of 8-point type (similar to *Readers' Digest*) at 10 or 30 footcandles. This is shown by the dotted horizontal lines.

(2) The light green board, which has a clean reflectance of 18 per cent and thus falls within the 15 to 20 per cent range shown in Fig. 4, requires 85 per cent more illumination to obtain the same relative visibility as the same task on the dark green board (10 per cent reflectance when clean). It is interesting to note that when the students in the test room were asked in a questionnaire "Which sample is easiest to read?", the dark green board was predominantly preferred. The teachers concurred with this opinion.

(3) The use of yellow chalk on either the light or the dark green board results in materially lower visibility than can be obtained with white chalk. In fact, 30 footcandles with white chalk produces about the same visibility as 60 footcandles with yellow chalk.

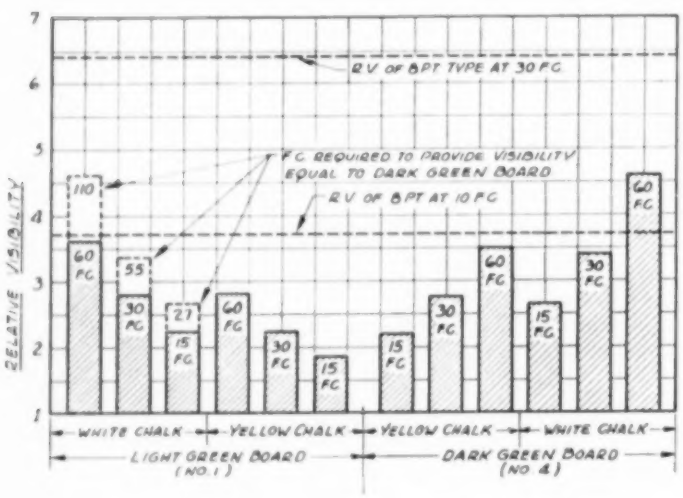


Figure 5. Chalkboard visibility at 18 feet distance for 20/20 vision.

The importance of good chalkboard visibility assumes even greater significance when one notes that the data in Fig. 5 are based on normal 20/20 vision with all readings taken only 18 feet from clean board. Approximately 30 per cent of the children in elementary schools have 20/30 vision or worse, and the visibility data is roughly proportional to the Snellen rating. The effect of distance on visibility is shown by Fig. 6, and it is evident that the problem is serious enough to warrant taking steps to obtain the maximum visibility that is feasible. It should also be remembered that the data are for clean boards; lower visibility will result when boards are chalked so that their reflectance is still higher.

Lighter chalkboards have been advocated to reduce the brightness ratios between the adjacent surrounds and the board to not more than 3 to 1. A study of the ratios in the test room is shown in Fig. 7. It can be seen that with a light board the ratios are well within the limit either with general lighting only or with the addition of supplementary lighting. It is also evident that the limit is exceeded slightly when the dark green board is used (4.6 to 1). This can easily be reduced, however, to less than 3 to 1 by providing supplementary lighting *on the chalkboard* only as shown by the last bar in Fig. 7. Since this additional lighting also increases visibility its benefits are twofold. Chalkboard lighting should be considered an essential part of every classroom lighting system instead of being reserved for the deluxe installations.

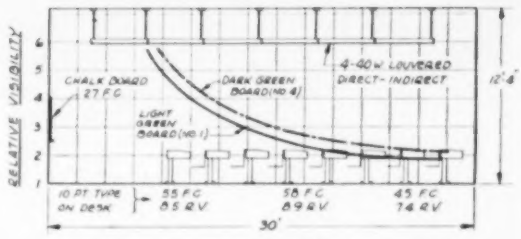


Figure 6. Visibility distribution in a classroom.

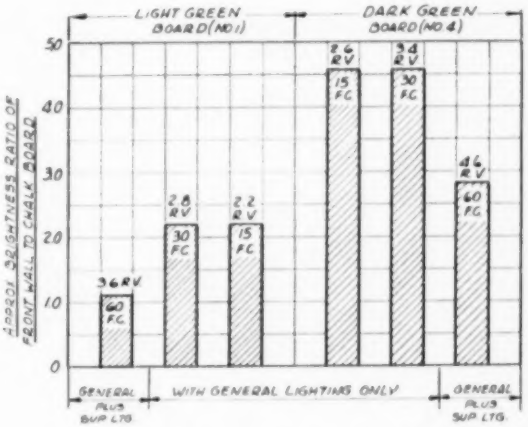


Figure 7. Brightness ratios of chalkboards.

Summary

Summarizing, it has been shown that it is possible to satisfy the luminaire brightness limitations set forth in the American Standard Practice for School Lighting with currently available luminaires that are practical and efficient. A new method of reporting and appraising luminaire brightness offers a further means of selecting luminaires that will provide comfortable lighting. By judicious selection of luminaires and properly finishing furniture and room surfaces to obtain recommended reflectances, good brightness relationships through the room may be easily attained. It seems wise, however, to temper our recommendations for high reflectances somewhat in the case of chalkboards where visibility may be adversely affected by a high reflectance. It should be recognized that the brightness of a surface is the product of its reflectance and the illumination on it. It follows, therefore, that the brightness of any dark surface, such as a chalkboard, may be increased by providing more light on the surface. This seems to be the obvious solution to the chalkboard problem.

It is hoped that this article has shown how lighting quality requirements for school classrooms can be satisfied without too much difficulty. A little extra care in the design of classroom lighting installations and a small additional investment in equipment and treatment of environmental factors can make the difference between success or failure in our objective to install lighting systems that are worthy of our nation's greatest potential asset —our children.

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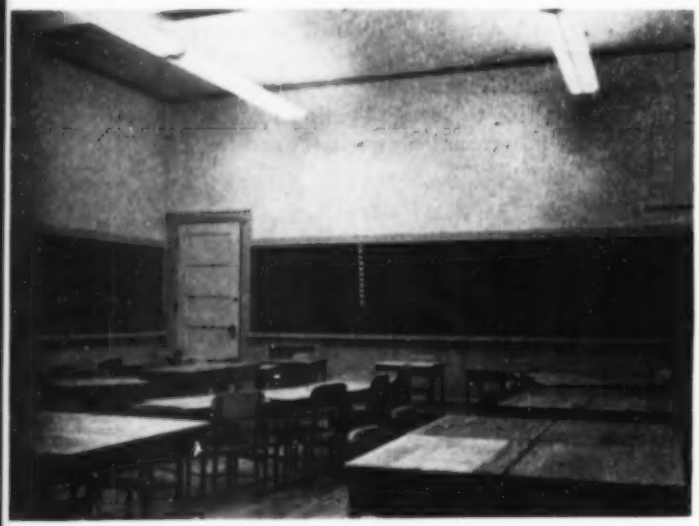
2. Jones, J. R., and Neidhart, John J.: "The Zonal Method of Computing Coefficients of Utilization and Illumination on Room Surfaces," ILLUMINATING ENGINEERING, Vol. XLVIII, No. 3 (March 1953).
3. Kahler, William H.: "Visibility of Chalkboards for Classrooms," *School Board Journal* (December 1950).

Two rows of two-lamp 40-watt louvered fluorescent luminaires provide 40 ft-c illumination in the home economics room (area, 36 x 22 feet) at Cathedral High School, Omaha, Nebraska (left). Units are mounted at ceiling height of 11′ 9″, on 10-foot spacings. Walls are white.

A high level of uniform illumination was designed for in the main dental classroom at the College of Dentistry, University of Southern California (right), to avoid strong contrast with the local lighting at each chair. Three continuous rows of low-brightness recessed troffers are spaced on 10-foot centers in the 10-foot-high acoustic tile ceiling. The classroom, which has over 60 dental chairs is 279 x 31 feet in area.

An average of 32 ft-c is maintained at the Halifax School, Winslow, Maine (below), with louvered fluorescent luminaires. Civic pride added the finishing touches, since parents contributed their time to sand and paint the desks in light colors. Slate blackboards were painted with a special non-gloss blackboard paint in light green.



Photos and data for the installations shown on this and the facing page were submitted by:

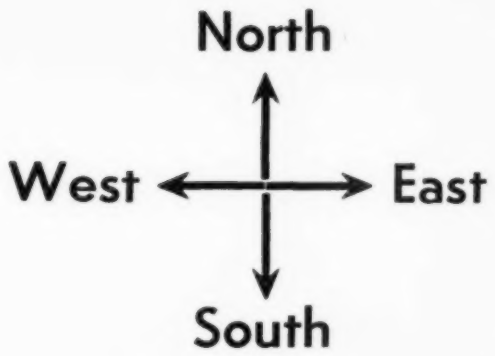
Cathedral High School, Omaha — E. B. McArdle, Omaha Public Power District.

College of Dentistry, University of Southern California — Sunbeam Lighting Company, Los Angeles, Calif.

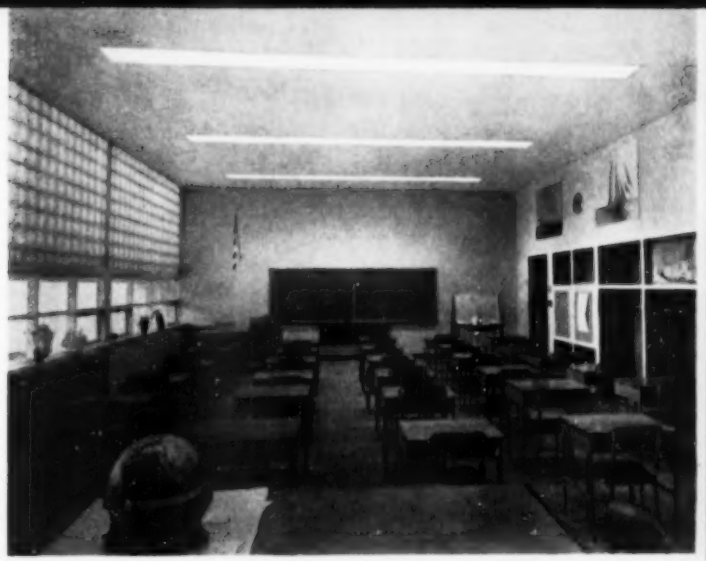
Halifax School, Winslow, Maine, and South School, Rockland, Maine — R. B. McFarland, Lighting Division, Central Maine Power Company.

Paul Lawrence Dunbar High School, Baltimore — C. J. Berry, Consolidated Gas Electric Light and Power Company.

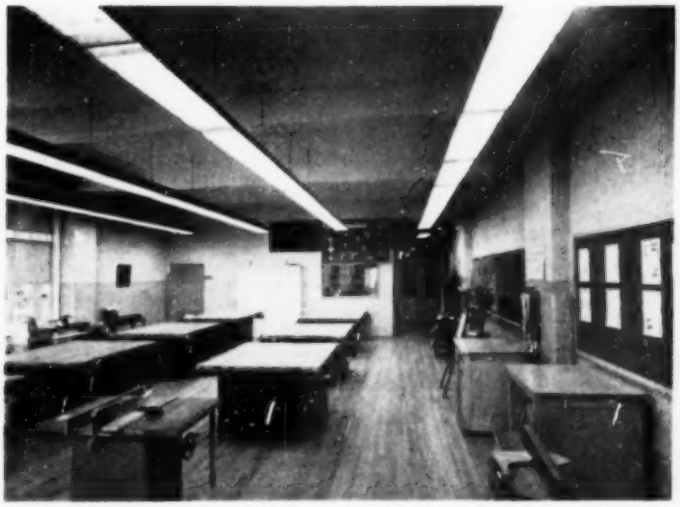
St. Anthony School, Forrest Hills, Kentucky — R. W. Brown, Cincinnati Gas and Electric Company.



Adopt Recommended Practice in Schools



Brightness balance between the recessed louvered luminaires and the ceiling, in the South School, Rockland, Maine (above), is well within recommended practice, because of high reflectance desk tops and floor. Glass block in window wall is light-directed.



The woodworking shop in the Paul Lawrence Dunbar High School in Baltimore (left), uses four continuous rows of two-lamp industrial louvered luminaires.

Bilateral daylighting with directional glass block adds to the fluorescent lighting in St. Anthony's School, Forrest Hills, Kentucky. Nine luminaires, each with two 75-watt warm white lamps, are suspended, in three rows, 18" from the white acoustic tile ceiling. Average maintained illumination is 50 ft-c. Walls are pastel green, floor is tan asphalt tile, desks light maple and chalkboards green.

Lighting for Classrooms With Nine-Foot Ceilings

By J. F. PARSONS

THE QUESTION has been raised concerning the use in low-ceilinged classrooms of bare cold cathode fluorescent lamps of somewhat lower brightness than that of standard hot cathode lamps.

On such luminaire employs four U-shaped bare lamps arranged horizontally at 90 degrees with each other. The overall (doubled) length of the lamp is about 45 inches. The lamp diameter is one inch, the rated milliamps 120, and the output varies from 1940 lumens to 2460 lumens, depending on the color. The lamp brightnesses associated with these outputs are respectively 1310 footlamberts and 1500 footlamberts. The brightness of standard T-12, 430 ma hot cathode lamps is about 1800 footlamberts.

Installations of this type of luminaire have been made in schools, presumably in rooms with standard height ceilings, with six luminaires in a 22 x 30-foot classroom.

The purpose of this report is to summarize some of the results of a preliminary study of the available data concerning the use of such luminaires in classrooms with 9-foot ceilings.

Brightness

Following is a comparison of the brightness of the bare lamp luminaire compared with the maximum recommended brightnesses from Table IV of the American Standard Practice for School Lighting:

Zone	Recommended Max. Brightness American Std. (with proper finishes)	Bare Lamp Luminaire
60 - 90° (hor)	450	1300
45 - 60°	900	1300
0 - 45°	2000	1300

It is calculated that in a room 25 x 30 feet with a 9-foot ceiling and with a .75 ceiling reflectance and .50 wall reflectance, the average illumination in service will be about 27 footcandles. The wall brightness against which the luminaires are seen will be about 8 footlamberts. Taking the brightness of the bare lamps as 1300 footlamberts, the brightness ratio of the luminaire and the wall immediately adjacent to it in the line of sight will be about 160 to 1. Following a similar procedure of calculation, it is found that the brightness ratio between the luminaire and the ceiling surface in the line of sight will be approximately 80 to 1. This should be compared with Table I of the Standard Practice in which the limiting recommended brightness ratio between luminaires and surfaces adjacent to them is 20 to 1.

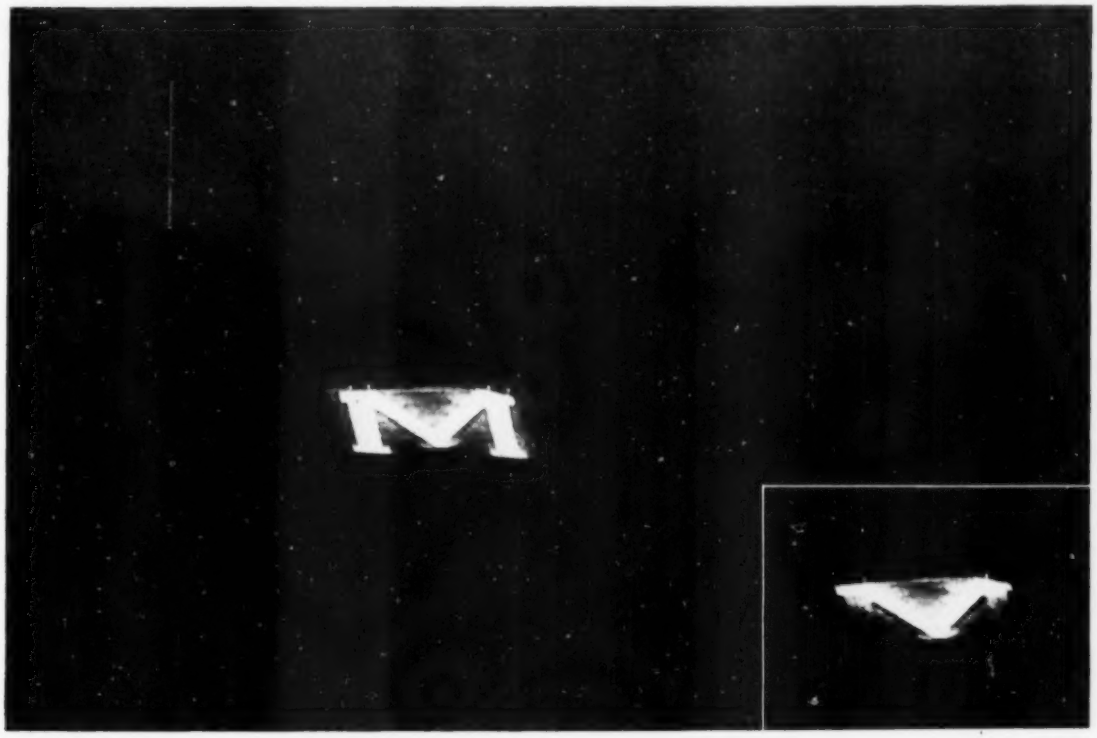
It should be noted that the requirements of the Standard are practical ones and are commonly attained in good present-day classroom design. The "Guide for Planning School Plants," published by the National Council on Schoolhouse Construction, is even more exacting, requiring a brightness ratio between the luminaires and their background not exceeding 10 to 1.

Discrepancies between these standards and the expected brightness from bare lamp luminaires, especially on 9-foot ceilings, indicates the necessity for very careful consideration. It is interesting to note that the brightness of a 14-inch globe with a 200-watt lamp is approximately 1100 footlamberts. The effect of six such globes in ceiling fitters on a 9-foot ceiling can be readily visualized or actually seen in a number of schools, although in the latter case the ceiling will be higher and the results, therefore, more favorable. The brightness of 1100 footlamberts associated with such enclosing globes might be compared with the 1300-footlambert brightness of the "low brightness" fluorescent lamps.

Another approach to the problem is through the Harrison glare factor, through which procedure glare is numerically evaluated. The calculations for a 25 x 30-foot room with six of these luminaires installed with the lamps 8 feet 6 inches above the floor indicate that the glare factor for lengthwise viewing will be approximately 180. According to Harrison, glare factors of 15 or less are acceptable for school or office use.

It is interesting to note in connection with ceiling height the glare factor varies directly as the square of the angle between the luminaire and the horizontal line of sight. Thus in a room with a 9-foot ceiling, the glare factor for a given luminaire would be more than double that for a room with a 12-foot ceiling.

AUTHOR: Niagara Mohawk Power Corp., Buffalo, N. Y.



INSTALLATION NEAR MONROVIA-DUARTE HIGH SCHOOL, MONROVIA, CALIFORNIA.

Lighting a Hillside Letter

LIGHTING OBJECTIVE: To illuminate a hillside block letter "M."

GENERAL INFORMATION: The letter "M," measuring 60 x 80 feet with an 8-foot stroke width, is constructed of crushed rock in a wooden frame. A local fire ordinance required all open wiring to have a minimum clearance of 16 feet.

INSTALLATION: Twenty-six Benjamin #5569 sign reflectors containing 100-watt A-21 lamps are spaced as shown in Fig. 3, with one S and M #800 floodlight containing a 200-watt PS-30 lamp installed below the center of the letter. All units are mounted on 5-foot rigid conduit stems from the surface of the sign, and the lights of the legs of the letter are wired on a separate circuit so that the "V" part may be illuminated alone after a football victory. The surface of the letter, all conduit, and the outside of the reflectors were sprayed with two coats of white highway paint, and glass reflector beads were hand cast over the paint before it dried.

The sign is clearly visible from a rival school nine miles away. No lamps can be seen from the front of the sign. At night the sign brightness measured at 45 degrees is 22 footlamberts; the ground along the sign edge is 0.8 footlamberts, and falls to zero about four feet from the letter.

The expense of damage from vandalism is minimized by the use of relatively inexpensive reflectors and lamps.

(over)

A.I.A. File No. 31-f

Figure 2. (above) Close-up showing lamps mounted above sprayed crushed rock.

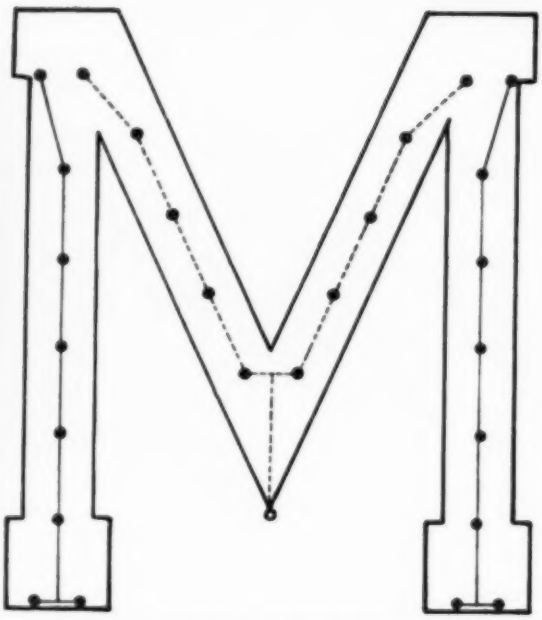


Figure 3. (right) Spacing of lighting equipment on sign surface.

Lighting designed by William R. Owings, Southern California Edison Company, Monrovia, Calif.; installed by Bruce Shields, City Electrician.

Lighting data submitted by William R. Owings, Lighting Consultant, Southern California Edison Company, as an illustration of good lighting practice and to aid in the design of similar installations.

Published by the Committee on Publications of the Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

The Common Sense of School Wiring

By MICHAEL J. FERON

ALL SCHOOLS, whether large or small, old or new have the ever present task of maintaining the important and functional electrical apparatus within the confines of their walls. Whether the maintenance is good or bad, depends to a large extent, on the initial design and installation. The problem of design can be readily resolved by entrusting the work to a competent and experienced engineer and the problem of installation should be performed by a reliable electrical contractor.

In order to obtain an efficient electrical wiring system, attention to small details is of major importance. It is, of course, required that there must be an adequate number of fixtures and outlets, and they must work. It is to this obvious end that many schools are being designed. The vital factors of *efficiency, future capacity* and *low cost maintenance* are often totally ignored. It is with this thought that the following recommendations are submitted.

The conduit used to carry and protect the electric wiring from the lighting panels to the fixtures and outlets should be, as often as possible $^3/_4$ inch inside diameter. The overuse of $^1/_2$-inch conduit restricts the wires unnecessarily, causing above-average heating and greatly reduces the possibility of pulling in additional conductors. This tends to prohibit future expansion. The extensive use of conduits larger than $^3/_4$-inch increases the over-all cost of labor and material.

The size of the conduit used to carry and protect the conductors providing electrical energy from the main distribution panel to the lighting and power panels should generally be larger than immediately required. This will provide capacity for future expansion at minimum cost. It is often difficult to install new conduits in an existing building without costly architectural alterations.

The current-carrying capacity of the conductors which constitute the distribution system within the building are governed by either the National or a local electrical code. It must be understood that these codes are *minimum recommendations!* They are not intended to cover the use and occupancy of each specific installation. The installer who seeks refuge behind these bare, minimum requirements, is apt to be performing a grave injustice to his client.

The lighting and power panels used throughout the building should be designed to protect the occupants. Consequently, they must be of "dead-front" constructions. This means that no live electrical parts are exposed. It is particularly important where students and teachers frequently use the panels. Panels should also be engineered with the maintenance men in mind. The space around the electrical apparatus within the panel should be large enough to house *all* of the conductors in an orderly and un-cramped manner. Cramping and packing wires into a small space injures the insulation, increases heat, decreases the capacity of the wire and introduces fire hazard. It also makes the job of the maintenance man twice as difficult when the electrical system is in distress or when additional wiring is required. Remember that good housekeeping applies here too.

When a circuit has shorted or a wire has burned out it is generally required that service be restored as quickly as possible. In order to facilitate repairs, circuit directories for the lighting panels should consist of an $8^1/_2$-inch by 11-inch photostat of the floor plan served by the panel, showing all fixtures and electrical outlets and their corresponding circuit numbers. The conduit and wires should not be shown. This will enable the electrician or maintenance man to go directly to the source of trouble. A lighting panel is poorly suited for long-winded literary efforts. When trouble is abroad, few men will appreciate the rhetoric of an electrical system. In order to use any circuit directory to maximum efficiency the wiring should be installed in accordance with approved drawings and the electrical loads properly balanced. All wiring should be color coded and banded with gummed bands, each stamped with circuit numbers and securely wrapped about the wires. These measures will enable the trouble shooter immediately to identify the circuits.

The task of rewiring old school buildings is often aggravated by the existence of obsolete equipment

AUTHOR: Electrical Engineer, Samuel R. Lewis & Associates, Chicago, Illinois. Paper submitted by the Chicago Section, I.E.S., Papers Committee.

and the high cost of installing new conduits. In many cases the present conduit and much of the present wiring can be reused. Before embarking upon a program of modernization, careful consideration should be given to the development of a master plan. This will enable the school to do all or part of the work immediately, or spread it over an extended period of time. It is costly and often dangerous to attempt a modernization program in a desultory manner. Think before you start.

The arrangement of ceiling outlets in old buildings is not always suitable to the installation of the equipment required for the modern and necessary high levels of illumination. These outlets, however, can be readily adapted to a new wiring arrangement by the prudent use of "oval duct" or "surface duct." "Oval duct" is a flattened electrical conduit which can be easily concealed in the thickness of the ceiling plaster. "Surface duct," as the name implies is a small dimensioned metal enclosure designed to be mounted on the surface of the ceiling. "Oval duct" and "Surface duct" are designed products intended to augment the existing systems of conduit.

In the majority of older buildings many electrical outlets and conduits have been abandoned or lost through the processes of alterations or repairs. A sizable portion of the rewiring cost can be saved if these conduits and outlets could be located economically. Any attempt to locate conduits long abandoned, is a costly and despairing process. There are, however, electronic devices available for this purpose, and in certain types of structures they perform satisfactorily. An alternate, and perhaps less costly, method is the use of compressed air. A flexible hose is connected from the air tank or compressor to the unknown or doubtful conduits which terminate in the panel. By releasing the compressed air into the conduit the unknown end can be readily detected by the hissing sound of the air. In stubborn cases where the end of the conduit is concealed beneath floor tile or behind plaster walls a stiff shot of the air will often break the plaster or lift the tile. The same method can be used in going from outlet to outlet. All that is required is a cone-shaped nozzle made of soft rubber which can be inserted into the end of the conduit.

Many older schemes of branch-circuit wiring made use of a system which placed fuses in both the positive and negative wires. This is commonly referred to as a "fused neutral." The two wires constituted one circuit. A general practice was to install two circuits in one conduit. Consequently this involved four conductors. These conductors can be readily adapted to the modern three-phase, four-wire system. Where once four wires produced two circuits, now the same four wires can produce three circuits. The old switch and fuse panels can also be replaced with a new circuit-breaker type panel which often provides half again as many circuits in the same space.

The design or re-design of any electrical system for schools should always include provision for adequate capacity, both for the present and the future, to accommodate not only the class and lecture rooms, but also the gymnasium, shops and theater or auditorium. Few people are cognizant of the large volume of elecrical current required to operate a modern theater stage, and the shock of realization at the eleventh hour is often more than the most well-rounded budget can sustain.

In general, therefore, it can be established that the hidden and un-aesthetic side of school modernization is dependent upon the little things as well as the major items. There is no substitute for a good job. It is either right or wrong. The following quotation more than emphasizes this fact.

"It is unwise to pay too much, but it is worse to pay too little. When you pay too much, you lose a little money — that is all.

"When you pay too little you sometimes lose everything, because the thing you bought was incapable of doing the thing it was bought to do.

"The common law of business balance prohibits paying a little and getting a lot — it can't be done.

"If you deal with the lowest bidder, it is well to add something for the risk you run, and if you do that, you will have enough to pay for something better."

I.E.S. Emblem

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Improved School Lighting . . . The Minneapolis Plan

By RUFUS A. PUTNAM
GILBERT T. LEE

A five-year rehabilitation program is underway in the Minneapolis school system with emphasis on relighting and refinishing of surfaces to meet the requirements of American Standard Practice for School Lighting.

MINNEAPOLIS public schools, like other large school systems, recognized many years ago that there was a great need for better school lighting. The hazards of the old drop cord, dangling-glass-shade lighting then existent prompted the administration to set up a committee on lighting to survey all school buildings. This committee included representatives of civic groups and the Illuminating Engineering Society School Committee of the Twin City Section as well as the Board of Education.

The first step in the survey was to determine the amount of illumination or lack of it in each classroom, special rooms, and corridors under various conditions: dark days, bright days, winter days, and summer days. The average reading in 2,200 classrooms was found to be approximately five footcandles!

The original committee set up in 1946 made careful studies of needed light for school buildings, but was unable to convince the proper authorities that the cost involved was warranted. During the year 1949, the administration re-examined the study and made some modifications. Its conclusion was that illumination levels for Minneapolis classrooms should be increased from 5 footcandles to 35 or 40 footcandles, and that interior painting of buildings in proper pastel colors was a part of the over-all lighting problem. Artificial and natural lighting, and interior painting complement each other.

Result of Studies

As a result of these studies, together with other surveys affecting school buildings, the Board of Education adopted a five-year rehabilitation program in December 1949 for the entire school system. The program was started in the spring of 1950, with emphasis on rewiring and relighting, and painting of school buildings. This part of the rehabilitation program has moved along according to the original schedule.

Before proceeding, the school architectural engineer, the general foreman of the electrical department, and the foreman of the paint department were authorized to attend illumination courses and view demonstrations, to study lighting methods, painting conditions, application of paints, and the kind of paints to be used. Every effort was made to develop the best lighting standards for the Minneapolis public schools.

Chalkboard Lighting

The studies of the committee showed the desirability of some form of auxiliary chalkboard lighting to provide the 30 footcandles recommended here. (The Committee had previously concluded that black chalkboards would be satisfactory.) Experiment showed that the standard system of overhead lights provided only about ten footcandles in a vertical plane at these boards. We decided on the use of 75-watt reflector lamps on adjustable sockets and shielded by hoods. These units brought the vertical illumination up to the 30-footcandle minimum and greatly improved visibility for students at the rear of the room. We are now considering a new type of fluorescent chalkboard lighting.

Another step to insure adequate lighting was the formation of a committee of experts to study and recommend the type of luminaire to be installed, method of installation, quantity, and arrangement; also the number of outlets in classrooms for other electrical apparatus, and technical requirements in proper wiring and lighting. Consideration was given to the color and quality of paint for classrooms. The membership of this committee included the school architectural engineer, general foreman of the electrical department, foreman of the paint department, nine illuminating and consulting engineers, chief electrical inspector of the City of Minneapolis, head of the Electric Workers' Union, and illuminating engineers from the Northern

Substance of an address before the Midwest Regional Conference, I.E.S., Minneapolis, Minn., May 1, 1953. AUTHORS: Superintendent of Schools and Assistant Supervisor of Buildings and Grounds, respectively, Minneapolis, Minnesota.

States Power Company. The lighting experts met periodically to explore every angle of school lighting.

Two major considerations in installation were the safety factor, and even distribution of light throughout the classroom. The experts decided to use a type of luminaire free from the hazard of falling or breakage. The average mounting height is about eleven feet above the floor, with spacing equal to mounting height. Each classroom is provided with two circuits of No. 12 wire for further expansion of electrical needs. Alternating current is used in all installations. In the classrooms where higher levels are required, such as drafting, typing and sewing room, an acoustical baffle system provides 50 footcandles maintained.

Cleaning or replacing of lamps, done by the school janitor, is extremely simple. A program of cleaning fixtures during Summer and Christmas vacation is being developed.

In addition to the old hanging lamps, there had been the hazard of electrical cords strewn across classroom floors to hook up movie projectors and radios. The Fire Prevention Bureau and the Industrial Commission had constantly advised elimination of these hazards. Consequently, when the rewiring and relighting of the schools began, the rewiring and installing of outlets was definitely a part of the job. A specific attempt has been made to complete the rewiring before the interior painting work is done in the building.

Rewiring Buildings

The policy of the administration has been to provide sufficient circuits, outlets, and lighting to enable a number of community groups to use the buildings with satisfaction. To consider facilities for adult use, the school principal, staff members, and Parent-Teacher Association members are called together by the general foreman of the electrical department to review over-all electrical needs in the building before electrical work is started. The common practice in Minneapolis is to install one outlet in the rear of the room for the movie projector and one in the front of the room for radios, television, and tape recorders. If a teacher has a special requirement for an outlet on a side wall for certain types of teaching aids, such an outlet is likewise installed. Outlets for corridor decoration, Christmas tree lighting, projection machines, and other electrical devices are considered. Diagrams showing location of heavy duty outlets for Parent-Teacher Association kitchen, teachers' lunchroom, and lunchroom facilities for students are prepared and checked by the people at the school who will use the electrical appliances. Every wardrobe, closet, and storeroom should be properly lighted. Exit lights in the auditorium, gymnasium, and school entrances are charted. Outside spotlights to illuminate the entrances for night activity are given a prominent part in the planning.

Since it is necessary to put new conduits in most of the buildings, every effort is made to eliminate the exposed and unsightly conduits in both corridors and classrooms. In some buildings, large conduits are being installed to accommodate wiring for an in-school sound system. Several elementary schools and junior and senior high schools have broadcasting systems with a control room and a small studio, so that groups within the building may produce radio programs, which may be transmitted to any or all parts of the building. Frequently, the school radio program is recorded or sent directly to one of the local broadcasting stations as a part of the "School of the Air," for public consumption. Through the sound system, the school can receive special local or national radio programs, which can be and are used as teaching aids in the classroom.

Program To Date

By the end of 1953, approximately 55 school buildings will have been completely rewired and relighted. The remaining 40 will receive treatment during the next two to three years. Most of the work so far has been done in elementary schools, because they are the oldest buildings and were in dire need of rehabilitation. The average elementary school has about 22 classrooms, whereas the average high school has about 65 classrooms.

During the three-year period, approximately one million dollars will have been spent on electrical work in the Minneapolis public schools, slightly less than half of the proposed program. Funds for this work have been made available through the issuance of school improvement bonds authorized by the City Council of the City of Minneapolis.

The reaction from school personnel, students, and parents to the results to date is most gratifying. The pleasantness of the rooms has been increased many fold by proper lighting and good interior painting. Letters of appreciation have been sent to the Board of Education and to the administration by students, teachers, principals, and parents. The morale of those who use the buildings has improved appreciably. All persons affected by the program had a part in planning the improvements, and each has a personal satisfaction of accomplishment.

Visual Requirements For Chalkboard Lighting

By R. G. HOPKINSON

This paper reports a study of the problem of lighting and vision in schools and makes special reference to the problem of chalkboard lighting. An examination was made of children's vision under chalkboard conditions with a range of illumination levels, which led to the conclusion outlined in this paper. The colouring of chalkboards was also studied and limits for chalkboard colours were specified on the Munsell scale.

IN RECENT YEARS there has been a remarkable revolution in the building of schools in England. During the war years the birth rate in this country went up considerably and all these children were found to be clamouring to enter schools during the period from 1948 onwards. In addition, there were movements of population from the centres of big cities which led to a demand for a large number of new schools in semi-rural and suburban areas.

Some education authorities (that is to say the local authorities, because in England education is still very largely under the control of local government) attempted to meet this demand for new schools by using traditional building methods. In other areas, particularly that of Hertfordshire (in which county the laboratories of the Building Research Station are situated), a new approach based on modern methods of prefabrication was initiated. Starting a technique from first principles in this way, the Hertfordshire authorities, under their chief architect Mr. C. H. Aslin and his deputy Mr. F. A. W. Johnson-Marshall (now chief architect of the Ministry of Education), were able to devote entirely new thought to the way in which a school should be designed. Working in close co-operation with their education officers they produced a type of school which is radically different from the typical English "church school" of the middle nineteenth century (Fig. 1) which remained for so long an example of an "ideal" school building for general education purposes. These new schools place considerable emphasis on the child as an individual and so devote considerable space to areas for play, for the storing of handicraft materials and for the free circulation of children between one part of the building and another, in a way which would have been thought unbelievable only fifteen years ago. Fig. 2 shows a view of a new school which has been built within half a mile of that shown in Fig. 1. It is unfortunate that children go first of all at the age of five years to the school with the modern outlook and then after

Figure 1. Interior of typical "church" school of mid-nineteenth century design.

Figure 2. Interior of typical Hertfordshire school built in the post-war era.

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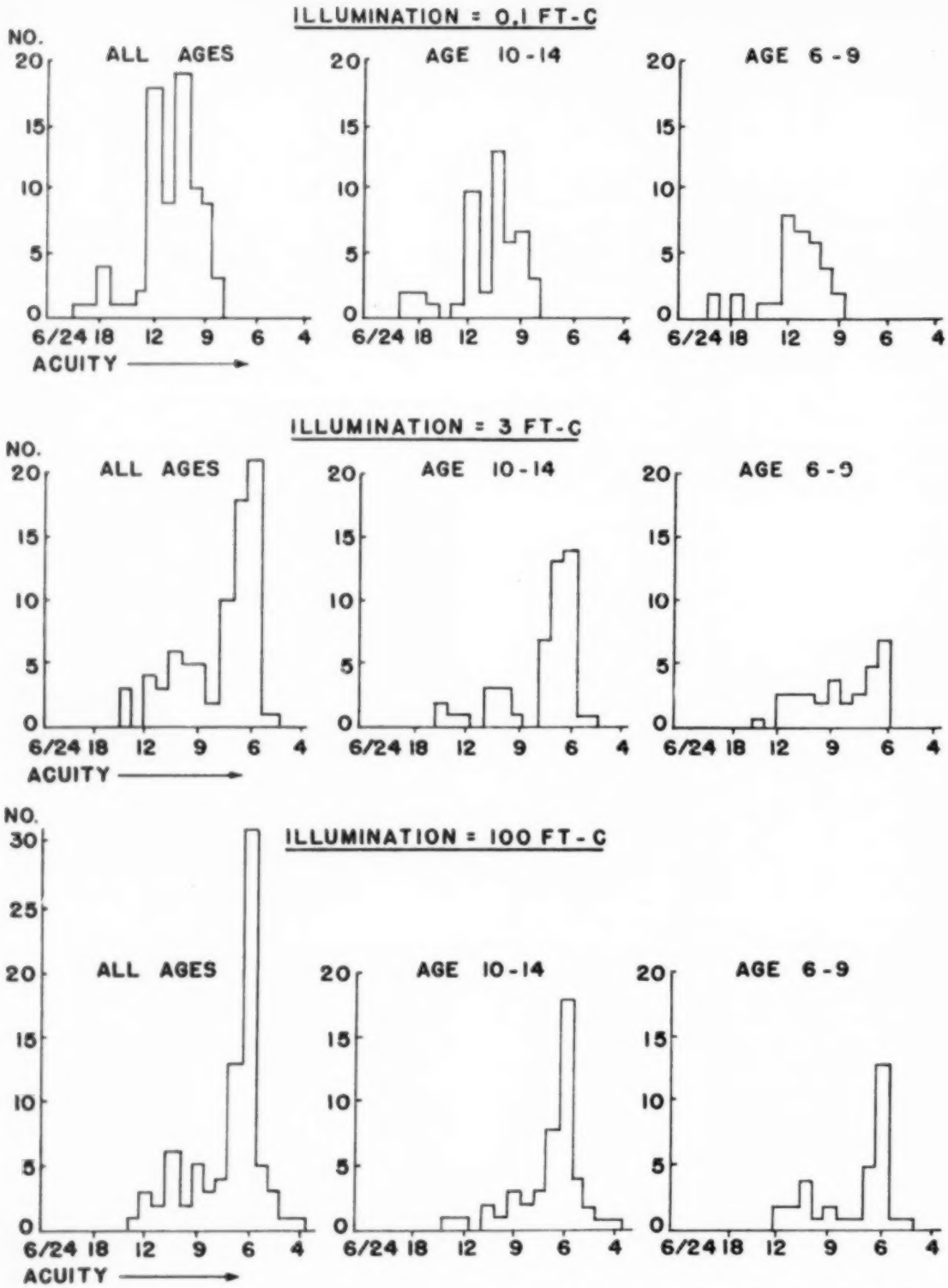

Figure 3. Acuity distributions of a normal sample of children divided into two age groups for "blackboard" chart.

three or four years in that delightful building move to the older school. It is not surprising that many of the children make the move with the greatest reluctance.

The Building Research Station has kept in very close touch with the Ministry of Education and the local authorities in all these new ideas on school building. The architects have made the fullest use of the technical advances for which the Station has been responsible and the Station has had the inestimable benefit of seeing its ideas put into practice at a much earlier stage than is usually the good fortune of a research worker.

The Building Research Station entered the lighting side a little late, since it has only recently been interested in the problems of artificial lighting, although it has for a long time played a leading part in work on natural lighting. Towards the end of the war a number of committees were set up under the aegis of the Ministry of Works in England to undertake the drawing up of reports on post-war building. One of these dealt with the lighting of buildings[1] and gives special attention to the problems of school design. The studies incorporated in this report drew attention to the need for adequate lighting in schools and led to regulations by the Ministry of Education for a minimum daylight factor in schools of 2 per cent. As the minimum value had previously been 0.5 per cent, it will be appreciated that a radical change in school design was being called for. Since the new schools had to be built to these regulations, the work of the Building Research Station and its associates was put into practice from the commencement of this new school building programme. On the artificial lighting side, however, the local authorities found that there was only pre-war work to guide them. Most of this work related to levels of illumination necessary for school tasks and told the school designer very little about how this illumination should be provided. School authorities therefore took one of two alternative courses: they either called in a lighting consultant or a lighting contractor and asked him to install artificial lighting to an agreed level of illumination (a minimum level of 12 footcandles) and left the job entirely to him how he did it, or else they undertook the task themselves, very often with inadequate knowledge of the principles of artificial lighting and being guided entirely by artistic considerations.

Neither of these alternatives was found to be satisfactory. The conventional lighting tradition of the contractor was based rather too much on industrial lighting practice to give comfortable lighting for school children. On the other hand the artistic architectural approach, while aesthetically satisfactory, rarely gives good lighting.

The chief difficulty was clearly seen to be that of discomfort due to glare. The lighting contractor was able to produce without difficulty the necessary levels of illumination uniformly over the whole classroom but the result was very often uncomfortable and was commented on as such by the teachers.

It was at this stage, when the major school building programme was getting underway in 1947, that the Building Research Station was asked to undertake a general investigation into the lighting of schools, both from the artificial and natural lighting standpoints, but giving first priority to the artificial lighting problem. It was decided to resolve the problem exactly as the architects themselves had resolved the school building problem, that is, by going right back to fundamentals and seeing what could be learned about the particular problems of lighting and vision in schools. The work which was undertaken has been reported in the Transactions of the British Illuminating Engineering Society[2] and this paper is concerned only with the problem of lighting of the chalkboard.

Children's Vision

Tests were made on the distribution of visual acuity in a sample of about a hundred children reading letters similar to those on a Snellen chart when arranged both in the form of black letters on a white background, that is the standard Snellen chart, and in the form of white letters on a dark grey background which is more comparable with blackboard conditions.

The visual conditions of the test were rather carefully standardised. The test chart was seen in the middle of a large grey background which was provided to avoid the distracting effects caused by harsh brightness contrasts in the immediate surroundings of the chart. The brightness of the room was also controlled to be of the order of, but rather less than, the brightness of the chart and its immediate surroundings, because experimental work had at that time indicated that these conditions were the most satisfactory for comfortable vision. This has subsequently been confirmed by more extensive experiments. Three levels of illumination on the chart and its surroundings were provided and could be readily selected. These levels were approximately 0.1, 3.0 and 100 footcandles.

The children were selected in batches and they waited in a room adjacent to the test room with the blinds partially drawn so that the average room brightness equalled that of the test room when the test chart was illuminated to the lowest

level. The children came in one by one and on entering the test room were asked to sit in a chair provided at a distance of 6 metres from the test chart. A few routine questions were asked while their eyes completed any remaining adaptation to the general room lighting.

Acuity of each eye separately and of both eyes together was then measured with the standard Snellen chart at the lowest level of illumination and was repeated with the "blackboard" chart. The illumination was then slowly raised to the second level and the same procedure was again gone through. Finally, the acuity was measured with both charts at the highest level. After the tests the child returned direct to the classroom without the opportunity to discuss the experiment or its results with his friends who were awaiting their turn.

Some considerable care had to be taken in assessing the acuity of these immature readers. Those who have had clinical experience will realize that the assessment of visual acuity by this method is not an easy task. For example, an increase in the illumination level often made little difference to the number of letters read on the final line but it made a noticeable reduction in the number of mistakes occurring in the earlier lines. This was especially noticeable in the case of younger children. The older the children the fewer these early mistakes, while a sample of adults, who were tested under similar conditions for comparison purposes, were usually found to read without error the line on which they first began to have difficulty.

It was noticeable that at the highest level of illumination the tendency of the child to lean forward in the chair to strain to see better was very much less marked, indicating a greater ease of seeing, even if no particular difference in visual acuity. A very brief summary of the results for the "blackboard" chart is shown in Fig. 3.

Data of this kind have to be interpreted with great care. It is possible to plot a relation between the average visual acuity and the illumination in footcandles. If this is done a curve will be obtained, familiar to lighting engineers and research workers both in the United States and Europe, showing a rise in visual acuity as the illumination is increased. This relationship does not, however, seem to be the whole story. Another way of looking at the data is shown in Fig. 4 where the illumination in lumens per sq. ft. (footcandles) is plotted against the percentage of children in the sample who were able to reach a given level of visual acuity.

If the desirable standard for children's vision is taken to be that of normal adult vision, there is obviously a good case to be made out for very high illuminations indeed on the chalkboard. The improvement continues up to 100 footcandles and has not reached a maximum at that level. Consequently there is no kind of optimum level of illumination, and the choice must therefore depend on the basis of assessment. If a satisfactory level for children's vision is taken to be two-thirds of that of normal vision then some clear indication emerges that there is a lower limit in the region of 3-10 footcandles.

Examination of the data in relation to age group also gives some interesting results. It is quite clear that the younger children have a poorer visual acuity than the older children. It does not necessarily follow that their vision is actually worse. The observed difference in the way in which the small children read their letters seemed to be almost entirely associated with the greater difficulty that young and immature intelligences have in interpreting the glared letters which they see on the chart. An older child or an adult will interpret

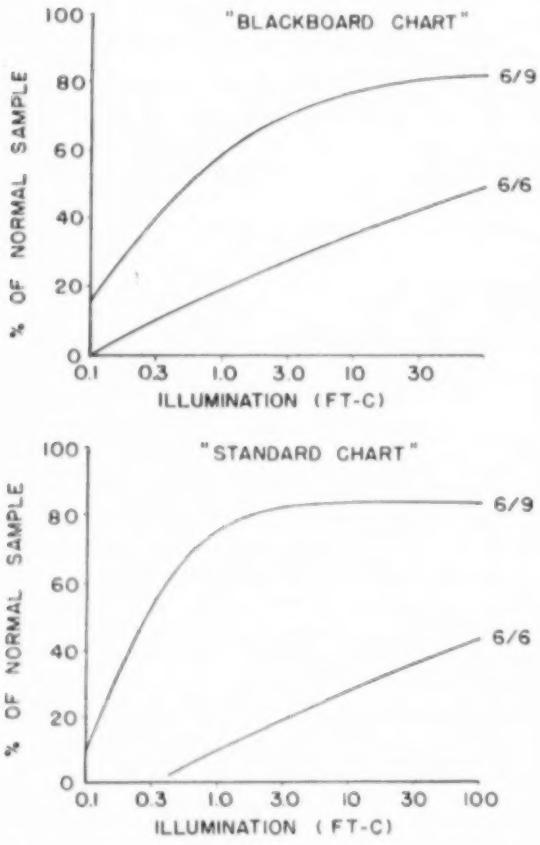

Figure 4. Proportion of normal sample with acuity better than 6/9 or 6/6 at different illumination levels.

each letter accurately because it has seen one like it before and knows what it is. A younger child cannot do this, even though it sees as clearly as the older child. It might be argued on this basis that younger children need more light on their chalkboard than older children. This argument could, of course, be sustained on the basis of the information provided by this test, but it must be remembered that the older children in general have harder visual tasks than the younger ones, and a study of the educational as well as the visual factors would suggest that the same level of illumination should be adequate for both.

Effect of Contrast on Visual Acuity and Ease of Reading

The next stage of the study was to find the effect of the contrast of white letters against backgrounds of different reflection factors and to see how the visual acuity of children with normal and also with indifferent vision would change with the variation of illumination on such chalkboards of different contrast.

It was unfortunately not possible to continue this work with child subjects. The investigations were extensive and the young observers could not be subjected to an experiment of this kind without taking them away from their school work for unnecessarily long periods. Reluctantly therefore the work was undertaken on a sample of young adults who had, however, made observations under the same conditions as those for which the data of Figs. 3 and 4 were derived. Allowances could therefore be made between the readings which they gave under the laboratory experimental conditions and those given by the sample of children.

It is not possible to describe in detail the full series of these experiments but they are referred to in the earlier publication.[2] Fig. 5 shows a typical series of results. The results are interesting in that at any given illumination level little improvement in visual acuity appears to result from increasing the contrast between the white letters and their background beyond a certain critical value. If the contrast is reduced below this value the acuity will fall off rapidly. The reflection factors for black chalkboards with white chalk letters corresponding to these critical contrast values appear to be about 40 per cent at 100 footcandles, 25 per cent at 3 footcandles and 6 per cent at 0.1 footcandles. The acuity achieved with these contrasts is of the same order as that achieved with the standard black letter on white background Snellen chart.

While the tests were being conducted, the comments and preferences of the observers were noted in addition to the measurements of their visual acuity. These comments were of some interest. At low levels of illumination observers clearly preferred the charts with white letters on the dark grey or black background from the point of view of comfort. At the higher level of illumination this also appeared to apply except that white on grey was sometimes preferred to white on black because some observers remarked that the latter was "glaring."

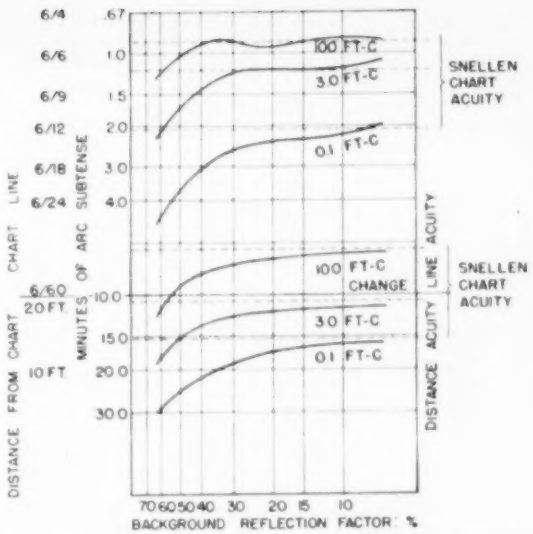

Figure 5. Average curves showing contrast vs. acuity for three levels of illumination, for white letters on dark background. Averaged curves for ten subjects with good visual acuity and for five subjects with poor visual acuity are shown.

It had been suggested by one or two ophthalmologists that the effect of lighting level on the visual acuity of children with poor vision might be much more marked than on that of normal children. It had even been suggested that good lighting would in some measure compensate for poor vision. The data collected were, therefore, also used to find the effect of illumination on the visual acuity of observers with less than normal vision.

It was found that to some extent observers with poor acuity show a greater improvement with change in illumination level than do observers with normal acuity, and in particular that this improvement is still being maintained at 100 footcandles, whereas with normal observers the improvement is practically static beyond 10 footcandles. On the other hand it was made clear that lighting alone cannot bring the visual acuity of those with moderate vision up to that of those with normal vision.

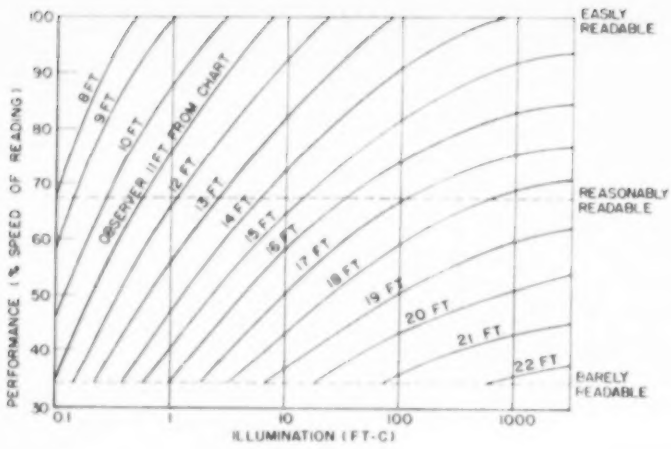

Figure 6. Effect of illumination on performance — average speed of reading referred to "easily readable" as 100 per cent.

Ease and Speed of Reading

The next stage of the study involved a rather more subjective type of experiment than that hitherto undertaken. In the past, work on the visual performance of observers has been confined either to responses of the Snellen chart variety or else to studies of the kind which have been systematised by Weston.[3] The present study was directed to a rather different end. It had been clear from the previous experiments that there was a factor which could be called "ease of reading," which was associated with the comfort of the subject in undertaking the visual task and not necessarily with his ability to perform it. Comfortable visual environments would appear to be just as important or almost as important in a school as efficient environments.

For this test the reading task consisted of a paragraph of about 16 lines with 150 words in Times Roman fount. Nine such paragraphs in all were photographed on separate charts and enlarged to such a size that the height of the letters corresponded to that of the "normal" line on the standard Snellen chart. Three of the charts consisted of black letters on a white background, three of them of white letters on a grey background (reflection factor 15 per cent, corresponding to an average black chalkboard) and three of white letters on a black background. One of each type of chart was used at each of the three levels of illumination, that is at 0.1, 3 and 100 footcandles. Finally the chart used first at 0.1 footcandles was used again at 3000 footcandles.

The experimental procedure was designed to eliminate the possibility of the observer learning the paragraph and hence influencing his speed of reading. The reading matter on each chart was selected to prevent as far as possible the same degree of difficulty and the same number of words. Once again great care was taken with the brightness of the surroundings in the test room. The observer came into the room and saw the chart at the far end of the room and was told to advance towards the chart until he could just see the first few words of the chart, which had been told to him previously. At this distance he could recognise these first words because he knew what they were, and perhaps he could also see some of the shorter words in the rest of the text (which he did not know), but he could not attempt to read the whole paragraph. This distance was described as the "just seen" criterion.

The observer then approached the chart until he was just able to read it through. It was as much as he could do to read the chart and mistakes would be made on the more difficult words, but he could just about finish the chart before he became too tired to read it all. This was called the "barely readable" criterion. The time taken to read the chart was noted.

The observer then advanced until, in his opinion, the chart was "reasonably readable." Here the criterion was that it was a strain to read, but that the words could be seen fairly well. The time of reading was again noted.

Finally the observer walked forward until the chart was easy to see, there was no strain involved in reading it and any further advance towards it would not in his opinion improve the ease of reading appreciably. This distance was recorded as the "easily readable" distance.

Individual characteristics tended to give a wide spread of the observations and it was of interest that observers who had good visual acuity as given by the Snellen test sometimes took a long time over

the reading test and vice versa. Some of these individual characteristics were followed up at a later stage.

A sufficiently satisfactory correlation was obtained between the criteria of ease of reading and the performance (expressed in terms of the speed of reading) to enable the results to be plotted in the form of Fig. 6. The conclusions drawn from the experiment were:—

(a) For a constant standard of ease of reading, equal proportional increases in illumination from 0.1 footcandle to 10 footcandles produce equal improvements in visual acuity as assessed by the critical detail of the reading test. Above about 10 footcandles rather more than proportional increases in illumination are necessary. This agrees with our knowledge of the relationship between visual acuity and the illumination level.

(b) For constant size of detail, however, equal proportional increases in illumination do not produce equal improvements in the case of reading. The more difficult the task (the smaller the detail), the bigger the increases in illumination necessary to produce a given improvement in performance. The greater the desired ease of reading, the greater the illumination increase is necessary to achieve it.

(c) If the observer is sufficiently near the reading task, that is the chalkboard, to be able to make an attempt at reading it at a low illumination level, then progressive equal proportional increases in illumination produce equal improvements in his performance and in his ease of reading. If, however, he cannot see the task at low levels of illumination, very high illumination levels indeed are necessary to effect a significant improvement in his performance and even then may not enable him to achieve maximum performance. Another interpretation of this is that if the illumination is low then increase it. If the illumination is high and the task is still not easy to perform then move nearer to the task.

A further factor which emerged from a careful study of the individual performances and preferences of the observers was that it was evident that within the range of the observers' "normal" acuity there is a very wide spread in the distances at which various degrees of ease of reading result. For example, three observers whose "Snellen" acuities were the same and were "normal," found that at 18 feet from the chart, their degree of ease of reading was quite different. One of the observers found the degree of reading to be reasonable whereas the other two considered it to be barely readable. This difference is probably associated with psychological difficulties in the interpretation of reading matter. Similar differences between other individuals show that it is of the utmost importance to take care in relating the Snellen acuity of a child to his reading performance in class. The Snellen test must not on any account be taken as a measure of his ability to read intelligible matter.

TABLE I.—Some Measurements of Factors Governing Visual Tasks in Schools.

	Range	Average
Reflection Factor of Chalkboard	7-33 per cent	16 per cent
Reflection Factor of White Chalk Letters	42-60 per cent	57 per cent
Size of letters on chalkboard:		
Printed capitals	5-9 cms.	7 cms.
Printed small	2·2-3·5 cms.	2·9 cms.
Script capitals	2·5-2·8 "	2·6 "
Script small	1·7-2·3 "	2·1 "
Numbers	1·3-3·0 "	2·1 "
Size of letters on Wall Charts (Small)	——	4·3 "
		2·2 "

Analysis of Visual Chalkboard Tasks

An analysis was made of visual tasks in schools by Medical Research Council investigators under the direction of Mr. H. C. Weston. Table I shows an analysis of some of the measurements which were made.

Colour and Contrast Preferences for Chalkboards

In addition to the performance and acuity data which have been referred to briefly above, a number of experiments were undertaken to find out how the colour and contrast characteristics of the chalkboard influence preference.

The first stage was to investigate the preferences expressed by observers when asked for their comments on the use of white on black, white on grey or black on white. At low levels of illumination (0.1 footcandle) the white on black chart was preferred by 6 per cent of the observers and the white on grey chart by 30 per cent. Only one observer preferred the black on white chart at this level, the other observers firmly objecting to it. At 3 footcandles the same order of preference was found but with much less bias against the black on white chart. At 100 footcandles, 50 per cent of the observers preferred the black on white chart and at 3000 footcandles the white on black chart was definitely not preferred. Most of the preferences for the white on black chart came from those observers who needed to approach closest for a given performance.

The next stage was to investigate the use of coloured chalkboards. Practical considerations, chiefly of expense, rule out the possibility of coloured chalk being used to any great extent in

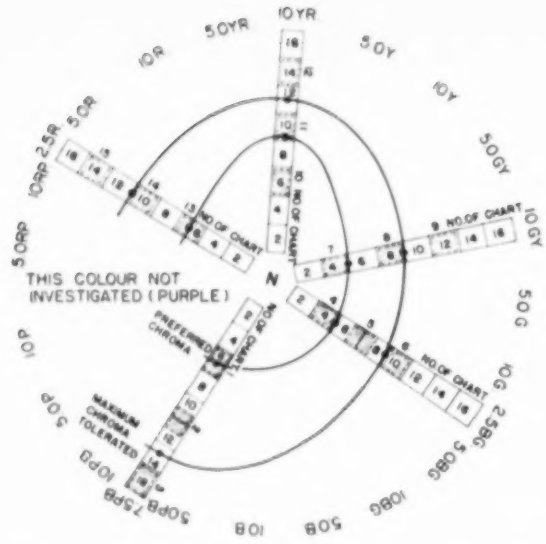

Figure 7. Coloured chalkboard preferences with white chalk letters. Horizontal sections of the Munsell Solid at value 5 (ρ = 25 per cent) showing positions of the 15 selected experimental chart hues and chromas, and loci of preferred and maximum chromas chosen by the 20 observers. Munsell hues are written round a circle of high chroma. Chroma numbers are written in the colour sample boxes: selected chart hues are cross-hatched in broken line boxes (chart numbers have been written alongside the corresponding positions). Circles represent the position of average amount of chroma considered preferable or maximum permissible by the 20 observers. Points obtained from the averages have been joined to illustrate the loci of "good" and "just acceptable" around the colour circle.

English schools. The study was therefore confined to the use of coloured chalkboards with white chalk. The increasing use of colour in English classrooms as an essential feature of their design demanded serious consideration of the use of coloured chalkboards because, unless careful study was given to the problem, it was likely that school architects might be tempted to use colours for chalkboards which were visually unsuitable.

The studies previously reported above show that the blackness of a black chalkboard is not a very important factor. Provided the teacher uses good solid white chalk letters the reflection factor of a black chalkboard can be quite high (up to 25 per cent — see Fig. 5). In fact, a consideration of all the evidence suggests that a dark grey of reflection factor about 15 per cent gives the best visual performance and the greatest comfort. The exact value is not at all critical, but if the reflection factor is above 25 per cent, that is above that of medium grey, visual performance does fall off. This assumes that the board is lighted to at least 10 footcandles.

If brightness contrast alone determined visual performance and comfort very considerable freedom in the choice of colour in the chalkboard would be possible. Unfortunately there are "clashes" between white letters and the coloured background when the reflection factor of the background is as high as 25 per cent, which do not occur with the grey background. The precise physiological reason for these clashes is not fully understood.

Fifteen small chalkboards with identical white printed sentences on each were used as test charts. Their background colours comprised five different hues with three different degrees of colourfulness and all fifteen charts had approximately the same lightness. These charts were displayed on a wall uniformly lit by daylight to an illumination of the order of 30 footcandles. The charts were displayed both in a random sequence and also arranged in groups of the same colour. They were all seen against a neutral buff shade (Munsell 2.5Y 8/3). Twenty observers were asked to place them in order of preference from the point of view of the presence or absence of dazzle or color clash. The results were subsequently analysed statistically and Fig. 7 was prepared from the results.

The results suggested the following rules:

(1) Highly colourful chalkboards must be avoided; otherwise serious dazzle will result.

(2) The maximum tolerable degree of colourfulness is about halfway between neutral grey and the maximum colourfulness which is possible.

(3) The preferred degree of colourfulness is about halfway between neutral grey and the maximum tolerable colourfulness.

(4) One is much more likely to overstep the mark using colours in the red, orange, yellow and greenish-yellow ranges than in the green or blue ranges.

(5) Within these limitations, chalkboards of a colour sufficiently positive to provide a natural focus of attention can easily be selected.

Conclusions

This work gives a fairly positive indication of what should or should not be done for the best visual use of a chalkboard. It is clear that the lighting engineer can only deal with a small part of the problem. The major decisions lie with the school designers and with the teachers who use the chalkboards.

Perhaps the crux of the matter is illustrated in Fig. 6. This figure shows how very much more can be done by keeping the children within a reasonable distance of the chalkboard as compared with adding illumination to it. Equally it shows what can be done if the teacher will only *write larger*.

For example, consider a child who is 14 feet from the chalkboard. With the test chart which was provided for the experiment the degree of ease of reading is called here "reasonably readable." In order to make the reading matter "easily readable" the illumination would have to be raised considerably. For example, the figure shows that "reasonably readable" at 14 feet corresponds to about 5 footcandles. To make the same reading matter "easily readable" would require 800 footcandles. Yet the same result can be achieved by moving in from 14 feet to 11 feet from the chalkboard. Similar figures can be taken from other parts of the diagram. Very roughly, a 30 times increase in illumination corresponds to an approach of about a yard nearer to the chalkboard or to an equivalent increase in the size of the lettering on the chalkboard. This should give new thought to both school designers and teachers. It is evident that there is a limit to what can be done by the designer and the teacher and it is at this point that the lighting engineer can lend his help.

On the basis of these studies the Building Research Station recommended to the Ministry of Education that no chalkboard should be lighted to a level of illumination, whether by natural or artificial lighting, less than 10 footcandles. This value of course is the absolute minimum which can be tolerated.*

In practice the greatest attention is being given to two main items. First, the provision of sufficient illumination on the chalkboard to make vision easy and comfortable and, second, the choice of colour and reflection factor for the chalkboard and its surroundings to make the chalkboard the natural focus of attention for the child. By so doing the child's gaze will automatically wander towards the chalkboard rather than, as so often happens, towards the dullest and least interesting (and therefore the most repellent) part of the classrooms.

All living organisms, children included, possess a phototropic mechanism. This mechanism automatically draws their attention to the brightest or the most colourful thing in the field of view. Children cannot be blamed if their gaze wanders away from a dull and uninteresting chalkboard, however vital for their education the material written on it may be. The lighting engineer and the architect together can, by the choice of a suitable colour for the chalkboard in relation to its surroundings and the provision of sufficient light on the chalkboard, produce a satisfactory visual focus which also gives good visual performance and visual comfort.

Recent studies on the effect of "contrast grading" on visual comfort during the performance of a visual task have suggested some ways in which these ends can be achieved.[4] Present practice in modern English schools provides a general illumination in the classroom of the order of 15 footcandles with between two and three times this amount on the chalkboard. The reflection factor of the chalkboard is maintained in the range between 10 and 20 per cent when the chalkboard is new, allowing for a certain suffusion of chalk dust during use which raises its reflection factor to between 15 and 25 per cent. Colour values are chosen from Fig. 7 to be as nearly as possible on the preferable range, consistent with the rest of the colour scheme in the classroom. The surroundings to the chalkboard are of high reflection factor, the phototropic effect being achieved by a greater colourfulness (higher chroma) and by the higher illumination on the chalkboard enhancing the subjective contrast between the white letters and their background.

The considerable amount of experimental data which has been briefly discussed above, together with extensive studies on the problem of glare discomfort and of contrast grading in relation to visual comfort, are only recently being put into practice in English schools. Thanks to the active co-operation of the school designers, especially the group under the chief architect at the Ministry of Education, these results and the conclusions drawn from them are, however, being put into practice much more rapidly than would normally be hoped for. In the realization of these ideas, compromises inevitably result and mistakes are naturally made. It is clear, however, from the results of schools already in operation that the principles are sound and are giving rise to a good architectural tradition.

The actual experimental work referred to in this paper was undertaken by a great many people, colleagues of the author and of the architectural development groups of the Ministry of Education and various local authorities in England. The author gratefully acknowledges his indebtedness to all these colleagues. The paper is published by permission of the Director of Building Research.

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*The American Standard Practice for School Lighting recommends 30 ft-c.—Ed.

Relighting—to Standard Practice

Relighting older schoolrooms to meet present-day recommendations is a problem being faced — and solved — in such installations as are shown on this and facing page. In many instances, community cooperation, in which businessmen's clubs, parents or the students themselves contribute to the program, may be the answer to the problem.

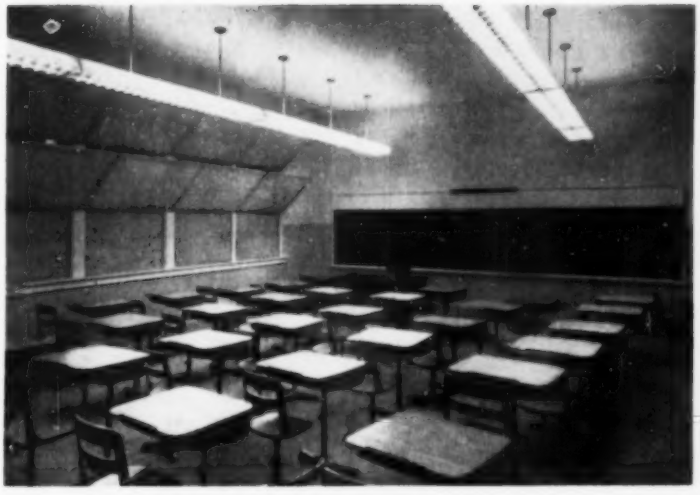
Typical of the relighting installations being made in Pittsburg, Kansas, is this sixth-grade classroom. A level of 70 ft-c is provided from three continuous runs of semi-direct 8-foot slimline units, with two T12 standard cool white lamps. The outer row of four units and the center row of three are surface mounted on the 9-foot ceiling. The inner row of four units is suspended on 36-inch stems from the sloping section of the ceiling. The rows are spaced on 8-foot centers. Decorations and finishes were planned for adequate reflectance and low brightness. Installation was designed by Carl Liebig, Kansas Gas and Electric Co.

Complete modernization of this classroom in Washington School, Greenville, Pa., was sponsored by the local Lions Club. Twenty fluorescent luminaires, with 40 per cent upward light, were installed in four rows one foot from the ceiling, and provide an average of 60 ft-c maintained. The room was completely repainted; with white ceiling and pastel green walls; furniture was finished in natural wood tone. Note the ivory-colored crayon board. Photo and data courtesy of P. G. Dingledy, Pennsylvania Power Co., New Castle, Pa. Installation designed by S. F. Beil, of the company's Greenville Division.

This room, at the Highland School, New Castle, Pa., serves both as a classroom and a library. Formerly lighted by five enclosing globes with 300-watt lamps, the room now has a maintained illumination of 55 ft-c from three rows of three 8-ft 4-lamp slimline luminaires suspended three feet from the ceiling. The ceiling was repainted a flat white, the walls pastel peach, and dado and trim a light gray. Installation was designed by L. E. Spears, New Castle Division, Pennsylvania Power Co.; photo and data courtesy of P. G. Dingledy of the same company.

This corridor in Liberty High School, Bethlehem, Pa., doubles as an art gallery. Seventy units of single row 40-watt strip with asymmetric Alzak reflectors give an average illumination of 75 ft-c on the pictures and 20 ft-c at the center of the corridor. The equipment was a gift from the 1952 graduating class. Photo and data submitted by Paul Hildebrand, Pennsylvania Power and Light Co.

Two rows of 8-foot 2-lamp fluorescent luminaires, mounted at 10 ft on 10-ft spacings, provide 48 ft-c in this classroom at Mount View School, Omaha, Neb. Fenestration is controlled by double diffusers of muslin stretched on a light wood frame and mounted on the windows at an angle of approximately 45 degrees. (The diffusers were made by the students' fathers.) This has the effect of directing the afternoon sunlight toward the white ceiling. Walls are light green, and blonde furniture is used. Photo and data courtesy of E. B. McArdle, Omaha Public Power District, Omaha, Neb.



Fundamentals of Lighting Maintenance

By R. R. WYLIE

ON THE BASIS of fundamentals of good economics alone, this article could very easily be summed up in three words "Keep It Clean." Much has been published of the strides which have been made in the techniques of good lighting; the ways in which the student environment can be changed to make a healthier, better place in which to learn. In other articles in this issue, the reader has glimpsed the progress which the electrical industry has made to provide the most economic and best seeing conditions for growing eyes. In dollars and cents there is a considerable necessary investment not only in the lighting equipment and wiring, but also in the finish of rooms, windows which provide natural lighting, furniture in the classroom, and in many other parts of a school which go into the make-up of the visual environment. It seems reasonable that this investment should be protected. It seems more to the point that those growing eyes should be protected along with the investment.

An analysis of the potential waste of money which can occur with poor maintenance may be of interest. Let us take as an example a typical schoolroom which was constructed to provide minimum American Standards Association recommended lighting levels — that is 30 footcandles at the working plane and correct brightness relationships between the luminaires and the various reflecting surfaces in the schoolroom. Further than this it is supposed that the initial cost of the lighting equipment is a dominant factor in the room design. Let us suppose that six of the popular concentric ring 750-watt silver bowl lamp luminaires were used and 32 footcandles were obtained initially.

If the maintenance is exceptionally good, it would be expected that at 750 hours life the delivered footcandles would fall to about 75 per cent of the original value, or 24 footcandles. If this installation were designed to deliver A.S.A. minimums of 30 footcandles at that point, eight fixtures would have to be provided to deliver the desired illumination.

Suppose there were average maintenance. At 750 hours life the delivered footcandles would fall to about 60 per cent of the initial or 18 footcandles and ten luminaires would have to be provided to maintain the desired A.S.A. minimums.

Suppose the school board had never heard of "Keep it Clean" and the maintenance was very poor — the custodian just replaced lamps. The lighting level could well fall to 15 footcandles or less and 12 or more fixtures would be required to keep the lighting within the A.S.A. minimum of 30 footcandles.

It is apparent then that the custodian can be a very important factor in reducing the school's initial costs, for whatever system is used. Additional factors should also be considered, because poor maintenance can *add* to the cost of operation.

1. Increased capital expense to be written off.
2. Increased energy expense for operation of the additional fixtures.
3. Increased lamp renewal expense because additional fixtures are required.
4. Increased maintenance expense because more fixtures have to be cleaned.

If maintenance is very poor, it is easily conceivable that the foregoing additional costs may overshadow the initial costs of the lighting. Thus it can be seen that planned maintenance, rigorously adhered to, is the least expensive way to sustain any lighting level when both initial cost and operating costs are considered.

Now, planned maintenance doesn't just mean that the custodian replaces lamps when they fail. Loss of light results from the natural depreciation of lamps as they grow older, from the accumulation of dust and dirt on reflecting or transmitting surfaces of the luminaires, windows, walls, ceilings and other surfaces. So, planned maintenance also means *cleaning*. Grimy windows, glass block controls and window shielding controls all reduce admitted "free" lighting to the classroom. Soiled ceilings, walls, dirty dark floors and desks absorb light. Dusty chalkboards reduce the maximum contrast obtainable by good maintenance for optimum seeing conditions. When well maintained, these factors all contribute not only to the extension of the economic life of the school structure, but also to reduced operating costs and to a healthier, more productive environment for the students. If the

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lighting losses mount through inadequate maintenance, the students do not have optimum seeing conditions, the building value depreciates, but the cost of the illumination remains unchanged.

It all adds up to one answer only — *Proper Adequate Maintenance Must Be Provided.* And how is that done? A general maintenance schedule should be set up. This schedule will vary according to the location of the school plant. Schools are built not only in the residential areas of cities, but also in the industrial areas. The atmospheric conditions in the industrial areas are a great deal dustier, grimier and oilier than in the residential areas. It is logical to assume that maintenance will be required more frequently in the industrial areas. Therefore, from experience, a seeing maintenance schedule should be evolved. The dirt accumulation rate of the locality can be established by a series of simple tests made either by the custodian, a delegated school authority, an interested lighting equipment manufacturer, or by a local public utility. If light meter readings are taken at stated periods, and the usual maintenance schedule for that particular school is adhered to for a period of a year or two, an indication should be obtained of the best operating schedule for good maintenance for that particular school, under its operating conditions. Periodic checks should also be made of the reflectivity of the finishes in the school rooms and these should be washed or repainted when the reflectivity drops by a maximum of 40 per cent. Windows and glass block fenestration should be washed regularly, for losses of as high as 50 per cent in light transmission through clear glass in a vertical plane in a six-month period have been observed. Surfaces of all exterior and interior shielding controls should be checked periodically and they should be washed or refinished at planned intervals. These tests and schedules should be set by the local authorities dependent upon how much light, seeing and investment they feel they can afford to throw away. Good maintenance is good insurance.

Such a program might be set up with the following factors keyed to the school operating year.

September	Make visual inspection — check footcandles.
October	Make visual inspection — wash windows.
November	Make visual inspection.
December	Make visual inspection — check footcandles, clean fixtures and relamp tagged lamps 750 hours old, check footcandles, wash windows.
January	Make visual inspection.
February	Make visual inspection — wash windows.
March	Make visual inspection — check footcandles.
April	Make visual inspection — check footcandles, clean fixtures and relamp tagged lamps 750 hours old, check decoration, wash windows.
May	Make visual inspection.
June	Make visual inspection — check footcandles.
July-August	Clean fixtures and relamp, check reflection factor of decoration, walls, ceiling and floors, and wash or repaint, if they have depreciated. Wash windows outside and inside and all light control devices, check footcandles.

Chalkboards should be cleaned regularly, to maintain maximum contrast. Floors should be cleaned regularly by methods which will keep reflectivity high.

Having established the need for good maintenance and a schedule by which it can be done, how does one go about doing it? That varies according to the locality, the size of the school system, the type of building involved, and the type of lighting equipment used. Generally, it involves the use of a cleansing agent and water. The "soapless soaps," or detergents offer one of the quickest and easiest ways to provide economical maintenance. The new non-rinsing materials will do the job efficiently and well for both the lighting equipment and the room interior and exterior surfaces. The School Purchasing Authority should consider ease of maintenance in purchase specifications. The initial cost is not always the lowest cost. Reflecting surfaces — glass, metal, plastic and porcelain — should stand up through many years' use and maintenance without undue failure. Any painted surfaces on lighting fixtures should be applied to a bonderized rust resistant metal surface and be finished with high temperature baked enamel, which will take variations in heating and cooling and strong detergent solutions over the years without yellowing, crazing, blistering or failing in other ways. Quite often the "lowest cost" equipment will not stand up under maintenance of the sort it must have in school use.

For particular applications of light sources, there is a whole gamut of maintenance techniques and problems which are too involved to go into here. Only general rules can be given:

1. Blackened lamps should be discarded — in incandescent applications, they show that the end of the lamp life is near. In fluorescent application, they show either that lamp life end is near or that there is a possibility of trouble in the operating system.
2. Each light source represents a contribution to the total light delivered in a room. With incandescent lighting this contribution per lamp is generally a large percentage of the total. With fluorescent lighting the contribution is smaller, but nevertheless as important. Therefore, failed lamps should be replaced.
3. Establish a lamp group replacement program

based on the actual hours use of the lighting equipment. In a large school plant, a group replacement program for the lamps, if fluorescent, can be set up at between 4000 to 6000 hours burning time. With fluorescent lamps today about 5 per cent lamp failures can be expected at 5000 hours in a large school installation. At 7500 hours possibly 50 per cent of the lamps will have failed. With incandescent lamps the 500-, 750-, 100-watt lamps have a rated average life of 1000 hours and generally will fail at about that time. So a group replacement program may be feasible there, too. As lamps grow older they give less and less light, therefore, lamps which have burned well into their life can be discarded because the useful delivered light obtained from old lamps is smaller. The cost of returning to the fixture to replace the lamp is high in relation to the value of the remaining life in the lamp.

As previously pointed out, it pays to get the best in reflector finishes. It also pays to get the best in lamps, auxiliary equipment and starters. With starter type fluorescent equipment it always pays to get cut-out type starters. If there is any doubt as to the quality of the equipment, generally the local utility can help resolve the question.

When this lighting-seeing combination has been installed, what will the results be?

1. Visual tasks made easier.
2. Greater visibility at chalkboards.
3. Brighter, more cheerful room atmosphere.
4. Greater attention by the pupils.
5. Better morale and higher teacher efficiency.
6. More light for the money invested in the school plant.

Only *Keep it Clean!*

"Beams of Light" from Luminous Panels

A "custom-built" appearance with standard equipment is a feature of this installation in the Perkins & Will School, Barrington, Illinois. The architect (J. S. Van Bergen of Chicago) wanted "beams of light" with a built-in appearance — and low cost. The unit was designed by C. T. Masterson and Leon Segil, to satisfy the architect's aesthetic requirements and to provide quality lighting, plus the additional element of sound absorption. The units are 32 feet long, each using seven two-lamp 40-watt fluorescent luminaires in continuous rows, shielded with strips of high transmission plastic and with metal acoustical baffles used as side beams. The architect was a bit unhappy with the unlighted plastic at the end of his "beams of light" and wished he had known to design the room long enough for another standard fixture; seven 4-ft (actually 4 ft ¼inch) being the maximum he had room for, just missing the room's full width. Lighting level is 50 ft-c maintained, with excellent comfort. Photo is courtesy of Luminous Ceilings, Inc., Chicago.

Pre-Testing School Design

HOW WILL a school design work in practice? Will the daylighting level be adequate? The distribution good? Brightness ratios within recommended limits? For good daylighting with lowest practical cost, should the ceiling height be 8 feet, 10 feet, 12 feet?

Questions such as these—on daylighting, ventilation, and later, sound, are being answered by actual test of scale models, at the Texas Engineering Experiment Station, Texas Agricultural and Mechanical College, College Station, Texas. The tests predetermine natural lighting and natural ventilation performance of proposed buildings and enable comparison of various architectural shapes. Measurements taken in full-scale test schools would seem to bear out the validity of the testing methods.

Director of the program is William W. Caudill, formerly an architecture professor at Texas A and M, whose own need for correlated data on elements contributing to environment (for his book *Space for Education*) led to its formation. Prior to these studies, published data covered only particular fields of study for daylighting, ventilation or sound, without relation one to the other in design construction. Now engaged in this program, in addition to Dr. Caudill, are Arthur W. Melloh, Vice-Director of Texas Engineering Experiment Station, Dr. E. E. Vezey, research physicist, Bob H. Reed, architect in charge of illumination design, and Dr. E. G. Smith, in charge of ventilation studies.

Testing Methods

Lighting surveys of existing buildings, it was felt, supply few bases for comparison. Sky conditions vary widely. So do landscaping conditions. Similarly, full-scale experimental rooms are subject to the extreme variables of available daylight, one day to the next, making adequate comparisons a slow proposition. Simpler methods of measuring performance of architectural shapes were investigated by the Texas researchers. The method they found most efficient and valid, however, was the exposure of scale models to test conditions. Daylighting performance for a given design is measured in a ten-foot "artificial sky" (Fig. 1). Careful investigation and trial determined the most suitable size of model, and construction details of the lighting hemisphere. Details of these investigations as well as results on specific tests have been documented in reports issued by the Texas Engineering Experiment Station.[1,2,3,4] With such methods, they have been able to test, relatively quickly, the effect of overhangs of different widths, predetermine performance of various designs, and make comparisons of numerous conditions. Lighting performance tests are rated for adequacy of illumination levels (30 footcandles being considered minimum), distribution of the illumination throughout the room, and quality as expressed by brightness ratios (10:1 considered minimum).

To obtain fundamental answers on another major element, ventilation, smoke tests (using titanium

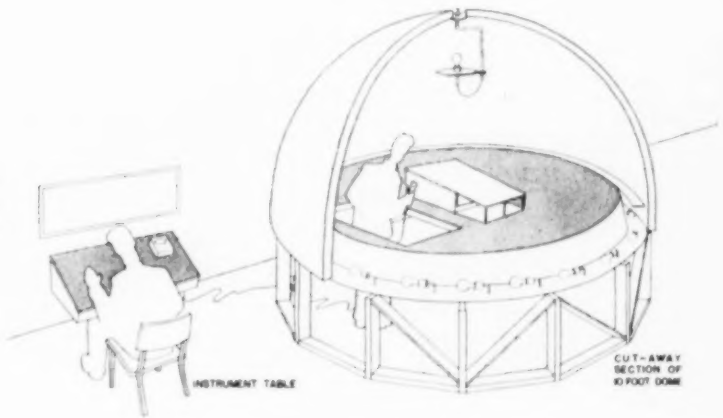

Figure 1. Ten-foot "artificial sky" in which daylighting performance for scale models of given designs was measured.

Figure 2. Air flow through a classroom is shown by means of a 2-foot model in the Wind Lab. When natural air flow is used to ventilate the classroom in cold weather, it is good to have the air flowing toward the ceiling in order to mix with the warm air at the ceiling and to avoid creating direct drafts on the students.

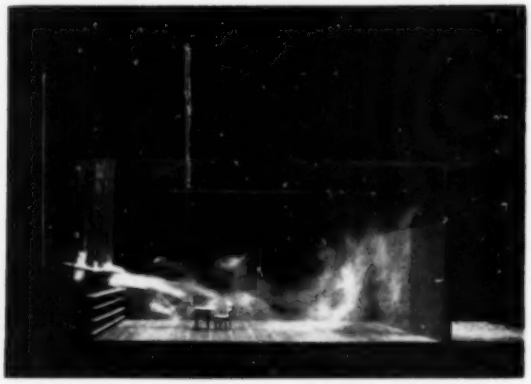

Figure 3. But when natural air flow is used to ventilate classrooms in hot weather, the air should flow directly through the living zone of the room and on the students. For maximum cooling effect of air movement in hot weather, according to the Experiment Station's reports, movement of air around, not above, the students' level is necessary.

tetrachloride to form a visible pattern of air movement) in a low-velocity wind tunnel permit the observance of natural air flow with models of various design (Figs. 2 and 3). Scheduled for similar testing, though not yet set up, is the additional element of sound.

Basic recommendations for design, in relation to the elements of daylighting and ventilation, are included in the published reports of the program.

Function of the Program

The daylighting-ventilation-sound test program at Texas Engineering Experiment Station has a three-phase function:

1. Fundamental research on building design as it affects light, ventilation and sound.
2. To conduct product studies for industry, to add to the knowledge regarding these elements.
3. Consultation and pre-testing, with architects submitting proposed designs.

For a long time engineers, architects and educators have wanted answers to such simple but fundamental questions as: How high should a ceiling be to maintain adequate illumination? What is the effect of variation in overhang on natural lighting and ventilation? Can better natural lighting be obtained in a classroom by sloping the ceiling? Where should windows be located for most effective ventilation? What size inlet and outlet is most efficient? Studies dealing with the geometry of classrooms as related to natural lighting and natural ventilation have provided answers.[2]

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1. The Feasibility of Using Models for Predetermining Natural Lighting. Research Report No. 21, Texas Engineering Experiment Station, College Station, Texas.

2. Geometry of Classrooms as Related to Natural Lighting and Natural Ventilation, by William W. Caudill and Bob H. Reed. Research Report No. 36, July 1952. Texas Engineering Experiment Station.

3. Research Activities of the Texas Engineering Experiment Station. Report No. 38, October 1952.

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Habits Do Change

The lighting industry has had an influence on schoolroom design which reaches considerably beyond the lighting fixtures themselves. Through I.E.S. committees, lecturers, lamp and fixture engineers, salesmen, and others, the use of light-colored paints and floor coverings has become wide-spread.

One of the most striking examples involves classroom desks. In 1945, and earlier, if a school superintendent wanted light-colored desks, they had to be purchased on special order and at an additional price.

By 1950, the reversal of usage was so complete that if a school system now wants *dark* desks, they must be purchased on special order and at an additional price.

WILLARD ALLPHIN

(Reprinted from the *Sylvania Lighting News*.)

A School Built To Pre-Tested Design

By ROBERT MacKINNON, JR.

A radical design for low cost bi-lateral school construction was proposed by this architect. To predetermine daylighting performance and effectiveness of sky glare control devices, scale models were pre-tested at the Texas Engineering Experiment Station.

THE DECISION to use a form of ground-reflected daylighting for the new wing proposed for the Darien Junior High School, Darien, Connecticut followed as a result of the architect's attempt to bridge the dollar gap between the cost of building good bi-lateral daylighting and the available construction budget.

Before dealing with the manner in which the quality of the natural light was to be underwritten, it was first necessary to determine in what way daylight was to be brought into the classroom. A series of surveys, based on quantities of materials required, showed us that a low-flat-roofed section could be built for relatively less cost than any of the standard monitor roofed or side-and-top lighted systems currently in general use. The design we proposed is shown in Fig. 1. State Education Department requirements, however, were such that a ceiling height of hardly more than one-third the width of the classroom would be acceptable only if evidence could be furnished to show that this comparatively low ceiling could provide adequate daylight through a deep classroom.

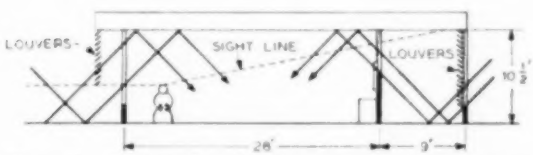

Figure 1. Cross-section showing lines of sight and light entering classroom.

This evidence was obtained through the facilities and kind cooperation of the Texas Engineering Experiment Station (a part of the Texas A. & M. College system). Meter readings obtained by William W. Caudill there on a scale model of the proposed section, showed that while an adequate amount of daylight was fairly evenly distributed throughout the space, brightness contrasts would be present between work surface and daylight source without some form of control of sky brightness.

The following possible methods of controlling the quality of the lighting were then considered:

(a) Venetian blinds, with their problems of maintenance, were rejected because field trips to existing installations pointed up two major faults:

1. It was found that rooms with the same exposure (*i.e.*, same sun and sky-glare problems) had blinds set in varying angles; therefore not consistently satisfying the end.

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2. It was apparent that even if the teachers were interested in keeping the blinds in the correct adjustment, it is doubtful whether, at the present time, they really understand the difference between sun control and sky glare.

(b) Directional glass block — while the material has the advantage of independence of human control, it was felt that the possible lower cost of clear glass plus some other form of sky shield would make further search worthwhile, especially if it would, at the same time, be possible to preserve a greater appearance of openness to the outdoors.

(c) Fabrics, paper, plastic — tests of these materials gave good results in cutting down glare without seriously lowering room intensities, but only in the absence of direct sunlight, thus limiting the usefulness of these materials to northern exposures.

(d) Natural features — trees, deliberate planting, etc. — ruled out because of the length of time it takes to grow a sky shield in the right place.

(e) Stamped metal sheets — samples tested had admirable glare-reducing characteristics, but failed to direct sufficient light to the ceilings.

(f) Exterior louvers — readings on the scale model showed that permanently fixed louvers could be expected to direct ground light to the ceiling evenly, yielding fair intensities, excellent distribution, and a very satisfying low level of contrast between brightness of work surface and brightness of the source of daylight at normal viewing angles. Another advantage of these louvers is that they serve as an ideal method of sun control. The actual solar radiation is reflected before it is allowed to penetrate the glass, as is the case when venetian blinds are used. This method was thereupon adopted, and the lower ceiling height was approved by the State authorities.

None of the methods outlined above will give protection from ground glare, but lawn and trees seem to minimize this problem at Darien. No field measurements for the effect of snow have yet been made there, but two conditions occur which probably help to alleviate this problem — greater increased overall room brightness as a result of greater ground reflection, and the east-west orientation of the classrooms, which, during the months of most likely snowfall, benefit from the sun's limited path in the south to the extent of avoiding incident reflection during school hours.

Reaction to the use of louvers in this school has been favorable on the whole, tempered with some quiet reservations on the part of a few of the teachers. It has been accepted with apparent enthusiasm by the students, who compared the absence of glare in their new classrooms with the lighting performance of the classrooms in the old building.

The present readings[6] have been taken in a room where there has been a slight modification to the original installation consisting of relocating the corridor louvers at the exterior glass corridor wall. As the reading shows, this change has improved an already good lighting condition.

[6] See "Daylighting Performance of a Pre-Tested School Design," by C. L. Crouch on the following page.

ASPSL, the "Standard Practice"

The ASIPSL, referred to so frequently in the papers in this issue, is the American Standard Practice for School Lighting, whose purpose is "To establish criteria of good illumination for the guidance of architects, engineers, school people, and others interested in the conservation of children's vision and in the efficiency of pupils and teachers." It covers both natural and artificial lighting recommendations for all types of school visual tasks. Approved in 1947 as an American Standard, this 80-page illustrated book (6 x 9-inch format) is available from the Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y. Prices upon request.

Daylighting Performance of a Pre-Tested School Design

By C. L. CROUCH

Tests on scale models of proposed designs for the Darien Junior High School predicted adequate illumination with good distribution throughout the room, and satisfactory sky glare control from the proposed system of louvers. Herein are shown results of illumination and brightness measurements taken in the completed structure, built to the pre-tested design.

THE daylighting objective of all designs is to utilize daylight to produce (a) as even a level of illumination across and throughout the room as possible, and (b) brightnesses throughout the field of view which are both comfortable and conducive to maximum visual performance. For years architects and engineers have thought primarily in terms of getting the daylight as efficiently and as uniformly into the room as possible through window proportions, but have left the brightness relationships to be considered only as a last resort by providing shades or blinds to cut out the offending brightness areas (reducing the light as well). Hand adjustable devices have left something to be desired because of the inadequacy of human follow-through. Practical experience and laboratory studies have united to demonstrate that present-day designers must place equal emphasis on the quality of illumination as well as quantity.

In the design of the Darien Junior High School fenestration, the architects' aim in control was not only the usual one of eliminating direct sunlight, but also to reduce sky glare. Louvers were proposed on both exposures to eliminate direct sunlight and cut down the average brightness of the glass area as seen from the interior. Scale models of the proposed design were pre-tested at the Texas Engineering Experiment Station. Evidence indicated the design's feasibility and at the same time suggested further modifications. Last year the school was built in Darien, Connecticut, to the final design specifications. In April 1953, measurements were taken in a typical classroom of the school, on both sunny days and on a dark day.

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The louvers, installed permanently approximately one foot ten inches outside the windows, are effective controls of sky brightness, as well as sun controls. As seated in the classroom, the eyes adapt to the average of louver brightness and brightness of the sky visible between the louvers. The angle of tilt, three-inch wide louvers fixed at 30 degrees from the horizontal, and their spacing (2½ inches apart) renders exterior objects visible to the occupants.

Bilateral fenestration was considered a "must" in a design aiming at uniformity of illumination throughout the room. In this design, however, light from the corridor side enters the classroom almost completely by reflection from the corridor floor, as indicated in Fig. 1 of Mr. MacKinnon's article on page 341 of this issue.

The original design provided louvers on the exterior of the outside wall of the classroom and on the corridor side of the glass between the classroom and corridor. However, later experimentation showed advantages (less change in eye adaptation when entering classroom from corridor, greater feeling of space within classroom, and cooler corri-

TABLE I.—Brightness Ratios.

	ASPSL Recommended Limits	Darien School	
		Sunny Day	Overcast Day
Between white paper and desk top	1 to 1/3	1 to ⅜	1 to ½
Between chalkboard and adjacent tackboard	1 to 3	1 to 2	1 to 2
Between paper on desk and floor	1 to 10	1 to ½	
Between chalkboard and brick wall	1 to 10	1 to 1	1 to 1
Between paper on desk and average of louver and sky brightness		1 to 35	1 to 25
Between chalkboard and corridor ceiling	1 to 10	1 to 10	
Between clear sky seen between louvers and louvers	20 to 1	14 to 1	6 to 1

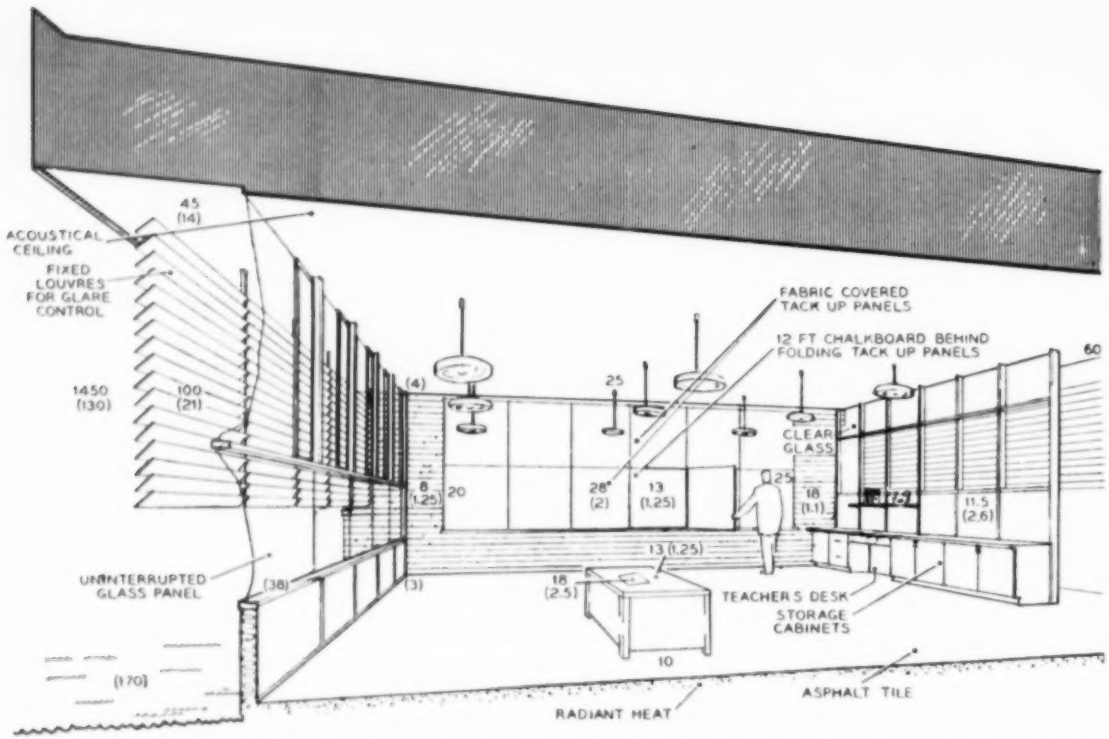


Figure 1. Brightness distribution on sunny day (horizontal footcandles in sunlight 4500, 560 footlamberts overhead sky brightness) with direct sunlight (5700 footcandles) on corridor fenestration. Values for dark overcast day (500 footlambert sky) are indicated in parentheses.

Table II.—Reflectances (Per Cent).

	American Standard Practice Recommendation	Darien School
Ceiling	80-85	75-80
Floor	15-30	40
Wall	50-60	
brick		20
tackboard		70
Desk Tops	35-50	45

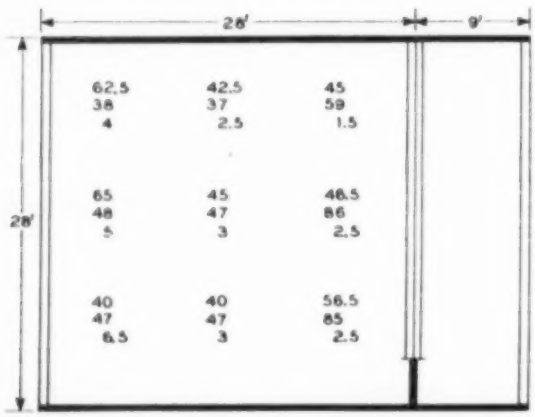


Figure 2. Illumination values (footcandles): top figure indicates value predicted from study of model; center shows measurement with sun on corridor fenestration, bottom figure is for dark overcast sky.

dors) in moving the latter set of louvers to the inside of the corridor glass. All the following data are for a classroom with the new arrangement.

Brightness distribution measured on a dark day and on a bright day with sun on the corridor, is shown in Fig. 1. Table I indicates the excellent quality of the resultant interior brightness distribution on a sunny day (5700 vertical footcandles incident on the corridor wall), and on a cloudy day. Table II shows the interior reflectances as compared with those recommended in the American Standard Practice for School Lighting. Although the interior brick wall is of a lower reflectance value than usually considered desirable for walls, from an illumination standpoint, most of it is adja-

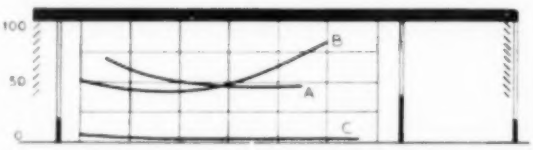


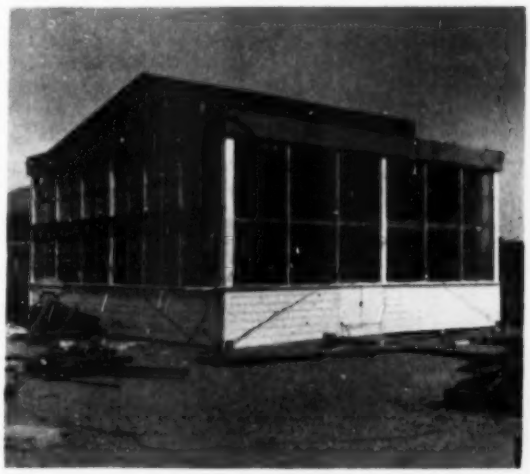
Figure 3. Illumination distribution across center of room.
A — predicted from model for uniform sky (1000 ft-L).
B — measurement with sun on corridor fenestration.
C — Dark day (500 ft-L).

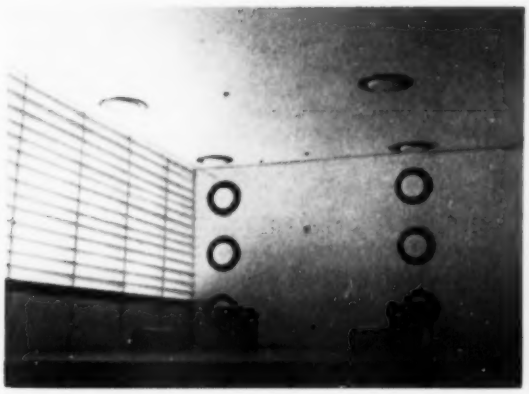
cent to the windows where the daylight is greatest, and under daylight conditions the brightness distribution is still within the limits recommended. In practice, much of the wall surface within the field of view is covered with relatively high reflectance tackboard, further contributing to the visual comfort of the overall area. Without sunlight, assuming a 1000-footlambert sky, Caudill predicted for the design finally used, values indicated in Figs. 2 and 3 (center figure). The same drawings indicate values measured in the actual school under a uniform sky of approximately 500 footlamberts (lower figure) and on a bright day with sunlight falling on one side (upper figure). The distributions do not agree exactly because of the sunlight and different ground reflections. Also, Caudill used a different interior reflectance pattern and reflectance of louvers.

These illustrations show that with sunny conditions the illumination is adequate (30 footcandles considered minimum). On a heavily overcast day the daylighting is very inadequate—much too low. This is true, however, with any kind of fenestration. Suitable high quality electric lighting is necessary to provide adequate levels on dark days in this school, as in all structures. Uniformity of illumination throughout the room is excellent with this design. (See Fig. 3.) This, together with the measurements shown in Table I, indicates the effectiveness of the design.

Daylighting Design Studies at S.M.U.

Other studies on daylighting are underway* at Southern Methodist University, Dallas, Texas, both with a test house and with an artificial sky. Photo at right shows full-size test house on a roof at S.M.U., which is used to check model tests. Below left is the $\frac{1}{4}$ scale model, with artificial sky, being used by J. W. Griffith, who is now directing the daylighting research activity at the university. Below right is the 1" = 1' model which is used for brightness studies.





*For results already reported on this work in ILLUMINATING ENGINEERING, see:
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Importance of Ground Reflection in Daylighting, by J. W. Griffith, O. F. Wenzler and E. W. Conover, January 1953, page 35.
A Lumen Method of Daylighting Design, by R. L. Biesele, Jr., W. J. Arner and E. W. Conover, January 1953, page 39.

Luminous indirect incandescent luminaires illuminate this high school library in San Fernando, Calif., to recommended levels. Eighteen units were used in the 45 ft x 73 ft area, suspended approximately 36 inches from the 14-ft ceiling. Lamps used are 750-watt silver bowl. Photo and data supplied by Dept. of Water and Power, City of Los Angeles.

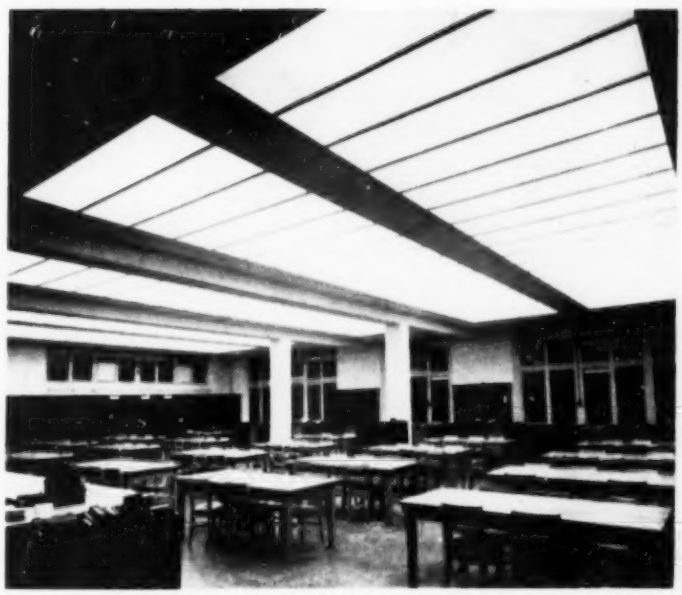
Comfortable High Levels in

Small children read in this library at the Fannie L. Barbour Elementary School, in Baltimore. Three continuous rows of six units each are used in the 27-ft 6-inch x 49-ft area, on a 10-ft 5-inch acoustic ceiling, to provide 30 ft-c. Lamps are T-8 standard warm white, 200 milliampere. Walls are light blue-green and all woodwork is blonde finish. Francis J. Thuman was architect and Turpin Wachter & Associates, engineers. Submitted by C. J. Berry, Consolidated Gas Electric Light & Power Co., Co., Baltimore.

School Libraries

I.E.S. requirements for library reading rooms have been met in this design for the La Salle College Library, Philadelphia. High reflectances on all surfaces, including the floor, combine with low-brightness recessed troffers to provide high level (66 ft-c) with comfort. Spacing is 3 ft 6 inches, in 11-ft ceiling, in a room 87 ft 6 inches by 23 ft wide. Design is by Fred A. Stewart, Haddonfield, N. J.; Lyle F. Boulware of Philadelphia was architect.

A translucent panel ceiling system featuring vinyl plastic in coffers was designed for the new library of the Glenbard Township High School, Glen Ellyn, Illinois, with excellent illumination results. Levels average about 42 ft-c maintained; note the vertical illumination on book stacks. Lighting was designed, cooperatively, by Paul Fisher, Public Service Co. of Northern Illinois, Downers Grove, Ill., and Samuel R. Lewis, consulting engineer. Architect was Clarence A. Jensen. Photo courtesy David H. Mason, Chicago.



Planning a Stage Lighting Installation For a Modern School Auditorium

By THEODORE FUCHS

FOR many years an installation of stage lighting for a school auditorium was considered adequate if it included footlights and several rows of borderlights. If these were set up in the patriotic combination of red, white, and blue colors, and if several receptacles were included to which could be connected an occasional spotlight or floodlight, the installation was considered better than average. If a switchboard were included, by means of which the footlights and borderlights could be gradually dimmed on and off, instead of merely switched on and off, the installation was considered an outstanding one.

Such evaluations lost their validity twenty-five years ago, and today have no justification as a basis for planning. The concept of what constitutes good practice in stage production has changed slowly and steadily over the years. For several years following World War I, however, it changed very rapidly. One feature of the rapid change during this period was the growing use of light for its inherent dramatic and artistic value beyond mere visibility. The qualities of light that made it potentially valuable as a medium of theatre art had been understood for many years, but it was not until the nineteen-twenties that proper equipment for their full utilization had become commonly available.

Basic Instrument of Stage Lighting

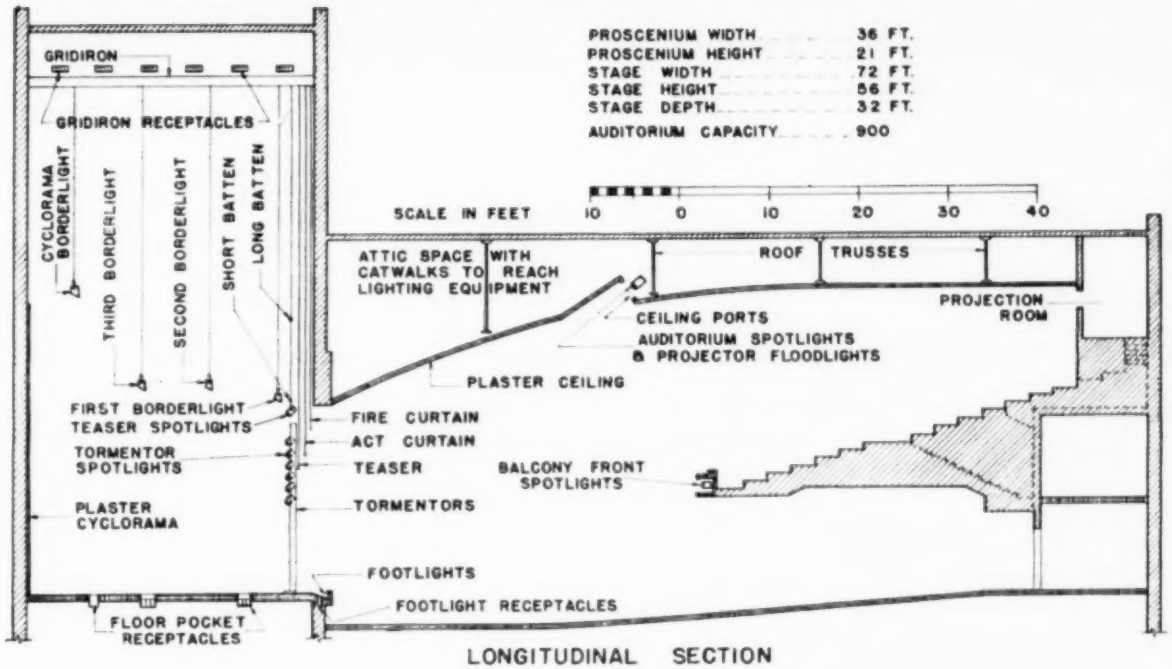
One result of this fuller use of light on the stage was the reversal of traditional stage lighting conditions. Footlights and borderlights had always been accepted as the basic and indispensable instruments for lighting a stage, supplemented perhaps by spotlights used for emphasis. After the change, however, which had been completed by the mid-nineteen-twenties, footlights and borderlights assumed a subsidiary position, and spotlights, now used in large number in the smaller sizes, had become the basic instruments. The reason for this is fairly simple. Footlights and borderlights, covering the entire stage area with a general flood of light, provide a utilitarian illumination that is essentially flat, inexpressive, and inflexible. A group of spotlights, however, through their individual beams of light, each of which can be widely varied in effect, provide not only good visibility over the stage, for basic seeing purposes, but visibility that is at the same time dramatically expressive and capable of a wide range of artistic possibilities. The use of spotlights as the basic instruments makes it possible to fit the lighting to the varying needs of different stage productions and to achieve a wide range of interesting results, whereas the lighting provided by footlights and borderlights has an unavoidable sameness from production to production. The value of footlights and borderlights today is that they provide a quick and simple means of supplying light over a large stage area when the stage is used for events that are non-dramatic in nature. Play production as an educational activity has experienced a vast expansion in recent years. In particular, the interest in stage production work in schools, and the standards applied to it, have increased greatly since the nineteen-twenties.

The first step, then, toward proper planning of an installation of stage lighting for the auditorium of a modern school is the realization that footlights and borderlights by themselves no longer constitute adequate lighting equipment. While these have a place in a complete installation on a multi-purpose stage, it is important that spotlights be provided in suitable types, sizes, quantities, and locations, along with proper facilities for controlling both the spotlights and the supplementary equipment.

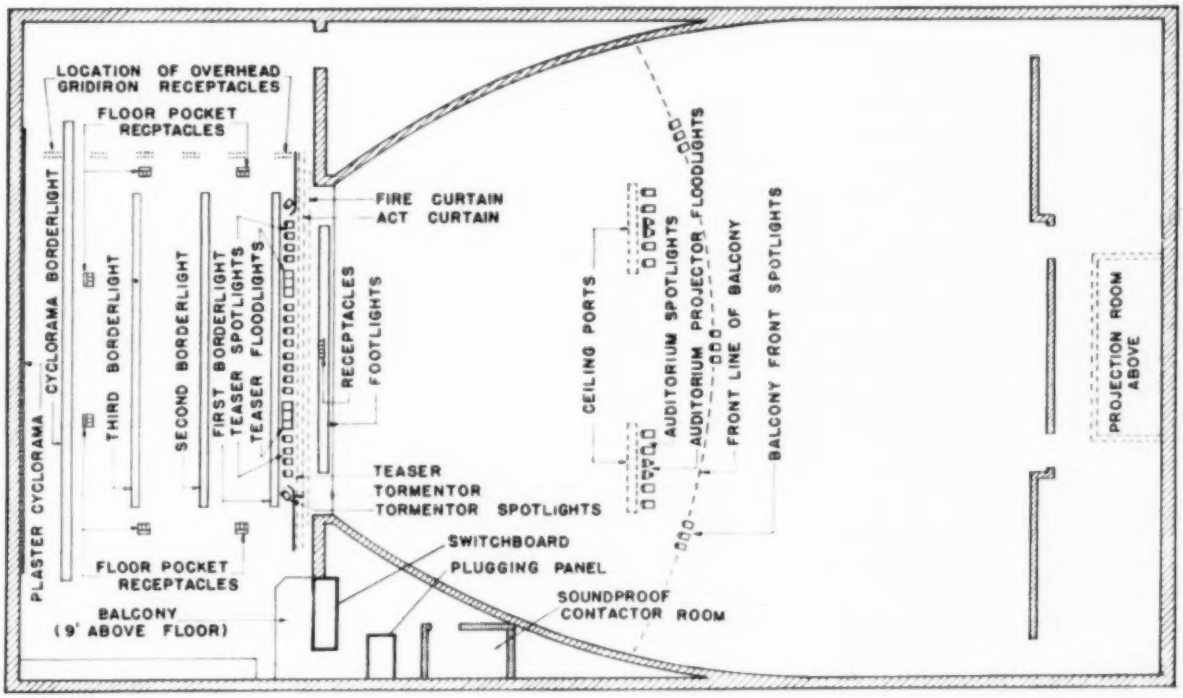
Auditorium Ceiling Spotlights and Floodlights

An extremely important location for these spotlights is in the auditorium itself. The auditorium provides the only vantage point from which light can be effectively projected onto the very important front areas of the stage. It is impossible to accomplish this from behind the proscenium. Mounting accommodations for these spotlights are provided in the auditorium ceiling, in the form of openings, or "ports," either in the ceiling itself or

AUTHOR: Professor of Dramatic Production, Northwestern University, Evanston, Illinois; and Consultant to Hub Electric Company, Chicago, Illinois. Paper submitted by Chicago Section, I.E.S., Papers Committee.



LONGITUDINAL SECTION



PLAN VIEW

Schematic diagrams showing location of stage lighting equipment for typical large stage.

in front of a false beam. Two functional principles determine the best locations for these spotlight ports. The first principle is that the light from the spotlights project downward onto the stage in such a direction that the center line of the spotlight beam will strike a point on the stage floor, about ten feet behind the proscenium, at an angle of between 35 and 45 degrees with the horizontal. Such an angle of projected light will provide the most favorable illumination for the actors in the front areas of the stage. Projection angles that are flatter or steeper than those suggested should be avoided. The second principle is that each of the front stage areas receive this correct downward light, not from directly in front, but from both sides at favorable angles inward, so that the actor will be well lighted for spectators at each side of the auditorium. The spotlight at each extreme side location is best placed just within a point opposite each side of the proscenium opening. The application of these principles, in an auditorium with not too low a ceiling, will result in most cases in two groups of spotlights at the auditorium ceiling location.

The port openings in the auditorium ceiling should be generous in size and should be in the form of a long wide slot that will accommodate several spotlights each, rather than many small holes for separate spotlights. The plane of the port openings should be perpendicular to the basic downward angle of the spotlight beams. These spotlights normally remain fixed for any production; they are not "operated" during performances except from the stage switchboard. Nevertheless, ample space for access, adjustment, and maintenance should be provided. Ventilating ducts above the ceiling should be routed so as to avoid conflict with these ports and their spotlights. The accompanying sketches show details of typical auditorium ceiling spotlight ports.

Auditorium spotlights located as described above are absolutely essential. For large stages several additional locations for auditorium spotlights might be given consideration, such as vertical ports in the auditorium side walls, relatively near the stage, for providing modelling side lighting for the front stage areas, along the balcony face, and from the motion-picture projection booth, these latter being particularly suited to large revues and operettas.

Provision for proper front lighting for non-dramatic events on the stage should be made by including in the ceiling ports, along with the spotlights, several projector-type floodlights. These will provide a pleasant, non-theatrical type of lighting for speakers and solo performers on the stage, and will effectively supplement the regular auditorium lighting, which is usually kept on during non-dramatic presentations.

Teaser and Tormentor Spotlights

The remainder of the permanently located spotlights for stage lighting are on the stage itself, mostly in overhead positions. The most important of these are immediately behind the teaser and the tormentors. The "teaser" is the vertically adjustable masking piece that constitutes the *top* of the false or inner proscenium opening; the "tormentors" are the two horizontally adjustable masking pieces that constitute the *sides* of the false proscenium. The teaser spotlights are mounted on a horizontal steel pipe batten suspended from the gridiron by one of the adjustable-height sets of rigging lines. The tormentor spotlights are mounted on a vertical steel pipe, or ladder, which forms part of the movable tormentor structure. Every effort should be made to conserve downstage rigging space (necessary for the fire curtain, act curtain, teaser, and tormentors, at least), so that the teaser and tormentor spotlights can be placed as far downstage as possible.

In the teaser position, there should also be provided several wide-beam floodlights, mounted on the same batten as the teaser spotlights. These are useful for covering the entire stage area with low-intensity light in deep colors, to bring out the color tonality of the stage settings and curtains.

The spotlights and floodlights in the auditorium ceiling and in the teaser and tormentor locations are connected to their respective plugging strips at these locations. The plugging strips contain the circuit wiring and the 2-wire 15-ampere receptacles into which the lighting equipment is plugged, and hence eliminate the hazard and unsightliness of a large number of separate cables.

The Cyclorama Background

Closely allied with the same trend in stagecraft that elevated the spotlight to its position of importance as a stage lighting instrument was the abolition of the realistically painted backdrop and its replacement by a carefully lighted white "cyclorama" background. This cyclorama may take one of several forms. In one, it is made of white-painted canvas, suspended from the gridiron near the rear of the stage and curved around the acting area at both sides. In its simpler and more common form it is generally a wide flat vertical surface of white painted canvas suspended near the rear wall of the stage. An often-used variation of this flat canvas

cyclorama consists of the full width of the rear flat wall of the stage, finished in a coarse sand-floated cement plaster, painted white. Each of these forms of cyclorama possesses certain advantages that make it particularly suitable to certain stage conditions, with the last mentioned form — the plastered rear wall being perhaps the most suitable to the average school stage. A cyclorama is an indispensable feature of every present-day stage, large or small, regardless of which particular form is chosen.

The flat cyclorama can be lighted most effectively by suspending a long cyclorama borderlight, with high-wattage lamps and well-designed reflectors, relatively near the upper edge of the cyclorama. For a curved cyclorama, the borderlight should be in short sections that can follow the curve. The cyclorama borderlight should be arranged in several color circuits, these to accommodate the light color primaries of red, green, and blue, with the latter predominant as to wattage, and these color circuits should each be divided into several section circuits, each assigned to light a certain vertical portion of the cyclorama.

Footlights and Borderlights

Footlights and borderlights today play a less important part in the lighting of regular dramatic productions than do the types of equipment already discussed. But the stage of the average school auditorium is often used for a variety of other purposes, however, and footlights and borderlights should always be included in a complete stage lighting installation, mainly because of the convenience with which their basically utilitarian lighting can be applied to the stage for nondramatic events. But even for such simple application, footlights and borderlights should receive careful consideration in their planning and installation.

Modern, single-row individual reflector type footlights, with colored glass roundels, supply a fairly suitable light at this location. Three color circuits should be provided, but in place of the prevalent red, white, and blue color combination, the light color primaries (red, green, and blue) should be used, as these together can provide a far wider range of hues, tints, and shades than is possible with the other combination. These color circuits should each be divided into several section circuits, so that it will be possible to isolate any color at specific sections of the footlight, usually left, center, and right sections.

The finest type of footlight is the indirect type. The lamps and reflectors are concealed beneath the stage floor. They direct their light toward the auditorium, but a continuous length of diffuse reflecting shield redirects their light onto the stage in a soft, well-blended glow that avoids the harshness and shadows that are almost unavoidable with regular footlights. The outstanding characteristics of indirect footlights should recommend them for quality installations.

Borderlights are mounted on steel pipe battens suspended from sets of rigging lines. As with the teaser lights, it is important that borderlights be adjustable for vertical height. For complete coverage of a stage, several sets of borderlights are required. The first borderlight should be located immediately upstage of the teaser lights, as close as physical clearance will permit. Additional borderlights should be located at intervals of from seven to ten feet, depending upon specific stage dimensions and the nature and location of other items of stage equipment. Each set of borderlights should be of the modern individual reflector type with colored glass roundels or sectional glass color frames. The reflectors in the first set of borderlights should be of the angle type, so that a fair amount of light will be distributed back into the upstage areas at times when a scenery ceiling will prevent the use of the upstage borderlights. Each set of borderlights should have three color circuits representing the three light color primaries — red, green, and blue. These color circuits should each be divided into section circuits, as with the footlights.

Worklights

Any installation of stage lighting equipment must include adequate provision for a high intensity of clear worklight over the stage. Worklights for the general on-stage area can be most conveniently incorporated in the borderlight equipment, using an additional circuit for worklights (similar reflector and clear glass color medium), for each set of borderlights.

These worklights, however, will not light the rear stage and offstage areas when scenery or curtains are in place; therefore, it is desirable to suspend, from the gridiron, several large "high bay" industrial-type reflectors over these areas at a height sufficient to avoid conflict with scenery and equipment on the stage floor. The worklight circuits in each borderlight and over each offstage area should be controlled by individual switches at the stage manager's station, and these switches should be duplicated at the stage switchboard.

Control Elements

The circuit wiring of the auditorium ceiling plugging strips, of the footlights and their receptacles, and of the floor pocket and gridiron receptacles extends in permanent conduit from these items to the plugging panel at the stage switchboard.

The teaser and tormentor plugging strips and the several borderlights are adjustable as to height or location. Hence the circuit wiring from these items must extend first by way of flexible multiconductor borderlight cable to gridiron junction boxes mounted under the roof beams, from which points it extends in permanent conduit form to the plugging panel.

The spotlights and floodlights in the auditorium locations and in the teaser and tormentor locations, the cyclorama borderlight, and the regular footlights and borderlights, can be considered as the fixed stage lighting equipment that remains in place permanently. The remaining necessary items of stage lighting equipment do not have permanent locations. They are considered part of the large amount of portable auxiliary equipment that is used as needed at various temporary locations, either on the adjustable overhead pipe battens which are part of the stage rigging system, or on portable stands or towers on the stage floor, or sometimes in the footlight position. These temporary locations are important ones, and any stage lighting installation must made adequate provision for readily connecting such units of auxiliary equipment to the stage switchboard for control.

Receptacles for their accommodation, in the form of "pockets," are required at strategic locations — in the stage floor, spaced around the general acting area, for the accommodation of portable equipment used at the stage level; on the gridiron or perhaps on the fly gallery, if one is to be installed), for the accommodation of auxiliary equipment mounted on the overhead pipe battens; and also in the footlight location. Connection between the auxiliary equipment and the pocket receptacles is made by lengths of stage cable. Most of these pocket locations should have two or more individual 2-wire circuits that extend from the plugging panel of the stage switchboard, and each circuit should be represented by a pair of 2-wire 15-ampere receptacles of the type that matches the plugs commonly used on the connecting stage cables and on the equipment leads.

Each individual circuit in the stage lighting equipment, as well as those in the receptacles of the various pockets and plugging strips, should extend to a "plugging panel" which is associated with the stage switchboard. The switchboard itself contains the "control circuits" which, with their switches, and dimmers, and other facilities, make possible a smooth control of the intensities of the lamps on the various "equipment circuits" that must be used for the various lighting effects. The plugging panel serves as the intermediary between the various units of stage lighting equipment and the switchboard.

The "control circuits" of the switchboard are represented at the plugging panel by several receptacles each. Each of the various "equipment circuits" is represented at the plugging panel by a single plug on a retractable cord, as on a telephone switchboard. At the plugging panel, the interconnections can readily be made between equipment circuits and control circuits, in any desired combinations or groupings that best serve the lighting control requirements of a particular production, or of a particular scene within a production. The electrical circuits that supply the general lighting for the auditorium, however, should be connected directly to dimmers on the switchboard. Unlike the stage lighting equipment circuits, they should not be routed through the plugging panel. Other types of interconnecting devices such as patch cords, selector switches, and cross-bar connectors achieve the same result as the retractable cord plugging panel and are adaptable to the smaller switchboard installations.

The plugging panel, or equivalent device, provides the stage switchboard with the all-important element of flexibility for the stage lighting. With a "flexible" switchboard, the switchboard can be readily adjusted to serve the varying lighting requirements of different productions. With a "permanent" type switchboard, lacking the intermediary plugging panel, the lighting equipment is permanently connected to the control circuits in fixed patterns, and the varying lighting requirements of different productions must be drastically changed to fit the rigid and limited control possibilities of the switchboard. As a result, lighting controlled by a permanent type switchboard has a monotonous sameness from production to production. The justification for a permanent type switchboard disappeared when spotlights replaced footlights and borderlights as the basic instruments for stage lighting.

Complete flexibility in a switchboard requires, in addition to a plugging panel, a type of dimmer that can provide uniform dimming characteristics for any size lamp load within the rated capacity of the dimmer. This requirement, in terms of types of dimmers available today, is met completely only

by the auto-transformer dimmer and by the electronic dimmer. This feature of a dimmer is important to a flexible type switchboard, as the lamp load connected to any dimmer may be 3000 watts in one scene and 400 watts in the next. A dimmer which cannot control either load with equal precision will deract measurably from the effectiveness of any flexible switchboard.

Aside from flexibility, which is undoubtedly the most important characteristic of a present-day stage switchboard and which is achieved by the use of a plugging panel and "full-load-range" dimmers, a stage switchboard should possess certain other features in order to be considered a completely effective device for lighting control. It should have adequate capacity in three respects: the total electrical load that it can accommodate; the number of equipment circuits that it can accommodate; and the number of control circuits that it has available. It should be provided with features that make for basic convenience of operation, and, if practicable, should also possess some refinements of control such as proportional dimming, several degrees of dimmer presetting, and scene-to-scene fading of all dimmers.

The location of the switchboard is a matter that should receive careful consideration. A direct-control switchboard with the actual dimmers forming an integral part of the board (as contrasted to the remote-control board with the actual dimmers at a distance from the board), must usually be placed somewhere on the stage, relatively close to both its main supply of electrical current and the lighting equipment which it controls. Probably the best location is at stage right, recessed into the proscenium wall, as far onstage as is feasible under performance conditions. The plugging panel should be located adjacent to the control board. This location for the switchboard and plugging panel could be at the stage floor level, or better still, elevated some eight or nine feet off the stage floor, with the operators working on a platform, above the crowded conditions that usually prevail at floor level. The stage manager's station, with its intercommunicating telephones and signal system, should be in close proximity to the switchboard.

A remote control switchboard (used with motor-driven and electronic dimmers) can be placed in almost any location, because of its compactness and light weight and low-voltage "pilot" wiring. Such a switchboard could be placed in a glassed-in soundproof booth recessed into the rear auditorium wall. This location has the great advantage of enabling the operators to see clearly the visual results of their operations at the switchboard, and to time and coordinate these carefully with the stage action. With the switchboard in such a front-of-house location, the plugging panel should still be located on stage. This requires facilities for constant intercommunication between the switchboard operators and their associates at the plugging panel on stage.

Auxiliary Stage Lighting Equipment

A certain amount of portable auxiliary stage lighting equipment is necessary to round out a complete installation. This should consist of such items as spotlights, floodlights, and striplights in various types and sizes; scene projectors; floor stands; lighting towers; and stage cable. One important guide to the planning of this auxiliary equipment is the principle that, to the greatest extent practicable, these various items of equipment should be readily interchangeable, both as to mechanical means for mounting them in place, and as to electrical means for connecting them to stage cables and to pocket receptacles provided for their accommodation as noted above.

Practice for Supplementary Lighting in Industry

The Recommended Practice for Supplementary Lighting, to be used with the recently published Industrial Lighting Standard, has just been released. This new 16-page report by the I.E.S. Sub-Committee on Supplementary Lighting will be extremely useful to anyone concerned with lighting an area or operation involving critical seeing in industrial plants.

The Practice deals primarily with the many critical seeing tasks involved in fabrication and inspection for manufacturing processes and recommends lighting to supplement general lighting systems. Various sub-titles of the report cover Analysis of Seeing Task; Supplementary Lighting Equipment; and Classification of Visual Tasks and Lighting Techniques. Tables give information in a form for easy reference.

Table III, for instance, classifies visual tasks and lighting techniques for each; Part I dealing with flat surfaces, Part II with three-dimensional objects. The table gives material and description of task involved; lighting requirements for each; suggests luminaire type and location. Other tables recommend brightness ratios and light reflectances for interior surfaces. Illustrations show a wide variety of properly lighted industrial operations.

Copies of the new Recommended Practice for Supplementary Lighting may be obtained from: Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y. Single copies, 50c; quantity prices on request.

Here and There with I.E.S. Members

Award winners in the Northern California Contest for "My Most Interesting Lighting Job" are, l. to r., seated, Merrill Humber, first prize; S. P. Russell, honorable mention; Raymond Benton, second prize; standing, Robert Thunen, Section Chairman; A. R. Parker, honorable mention; R. L. Sawyier, third prize; J. S. Walsh, Contest Committee Chairman. Photo by William Cyr, *Electrical West*.

A total of 72 members and guests attended the April 2 meeting of the Southern Colorado Chapter at which President Strong was featured guest. At the head table are Mrs. Strong; Mrs. C. D. Bell; C. D. Bell, Chapter Chairman; President Strong; H. T. Rankin, Inter-Mountain Regional V-P, and Mrs. Rankin. Those attending considered this meeting as a spontaneous "Regional Conference."

The 40 members of the Quebec Chapter, who made a trip to Shipshaw generating plant and to Arvida as guests of the Aluminum Company of Canada, Ltd., had lunch at the Saguenay Inn.

Check for first prize in the Michigan Section contest for "My Most Interesting Lighting Job" is presented to A. C. Sangster by Contest Committee Chairman E. W. Pratt. The winning lighting installation was at Our Lady of Grace Roman Catholic Church.

Some members of the Data Sheet Committee of the Chicago Section at one of their meetings are, l. to r., top row: G. L. Benbow, G. Nordeen, W. M. Walsh, G. Jakes and W. M. Snyder; bottom row: A. M. Koga, J. T. Dunne, Chairman W. M. Coffey, R. Alkire and W. Beyers.

TELECAST

LIGHTING NEWS OF CURRENT INTEREST

Pacific Northwest Holds Seventh Annual Regional Conference

Special appeal to associated groups was a particular feature of the I.E.S. Pacific Northwest Regional Conference in Portland, April 2-3. The two-day meeting was attended, in addition to I.E.S. members, by a number of architects, consulting engineers, contractors and educators. Formal registration included 121 men, 25 ladies who, with local guests and visitors brought the total attendance to 141. Site of the conference was the Benson Hotel, Portland, the Oregon Section of I.E.S. serving as host.

Walter E. Potter, Conference Chairman, opened the meeting with the introduction of Mayor Fred L. Peterson who addressed the group, placing special emphasis on the importance of lighting in all aspects of commercial, industrial and home living. Walter J. Lind, Regional Vice-President, responded appropriately and turned the meeting over to Paul Donnelly, Chairman of the British Columbia Section, I.E.S., who acted as session chairman for the morning. The opening session featured the following papers:

1. An Architect Looks at Lighting, Douglas C. Simpson, M.R.A.I.C. Architect of Semmens and Simpson, Vancouver, B. C.
2. An Optometrist Views the Lighting Profession, Dr. Howard C. Hall, Optometrist, Seattle, Wash.

The afternoon session chairman was Clarence A. Scheyer, Chairman, Puget Sound Section. The program consisted of:

3. Trends in Lamp Development, C. M. Cutler, Application Engineer, General Electric Co., Nela Park, Ohio.
4. Street Light Developments, W. B. Gero, Manager, Commercial Engineering, Westinghouse Electric Corp., Bloomfield, N. J.

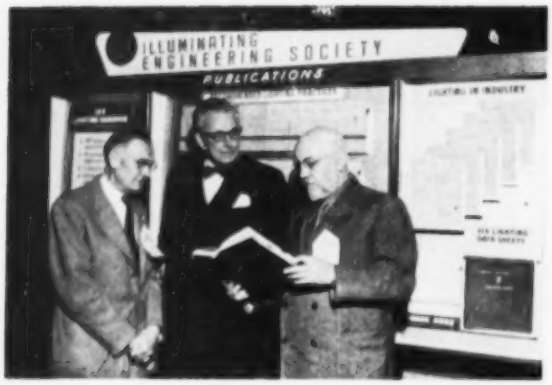
The latter part of the afternoon session was devoted to five presentations of "My Most Interesting Lighting Job," from the various chapters in the area. Don E. Frank of the Inland Empire Section won first prize with his story on "Bank Lighting." H. H. Arnold, British Columbia Section came close with his interesting and well prepared presentation on Home Lighting. Chairman Clarence Scheyer closed this session by urging I.E.S. members to encourage this contest locally.

An informal banquet Thursday evening highlighted the social program. The main feature of the banquet was the Student Branch Charter presentation to the Oregon State College made by Walter Lind, Regional V P. He recommended that all sections in this area emulate the Oregon Section's example in this valuable I.E.S. student participation. Professor Delbert Shirley of Oregon State College, responded by urging all present to encourage student interest in lighting by hiring these students after graduation. Highlight of the evening program was the rendition of popular songs by the "Chantsonettes," a group of twenty girls.

Several special tours were planned for visiting ladies on Thursday, including a trip to points of interest in the Portland area.

Session Chairman Ken Reid, Chairman of the Vancouver Island Chapter, opened the Friday morning program, and introduced Edward Rambusch, President of Rambusch Lighting, New York, who gave an excellent and practical talk on Ecclesiastical and Institutional Lighting. The next speaker, W. B. Gero, manager, Commercial Engineering, Westinghouse Electric, spoke on Trends in Light Sources. "Monte" Cutler of Nela Park spoke and illustrated "Environment with Lighting."

Technical sessions had special appeal to associated groups of architects, consulting engineers, contractors and educators.



Ray Preston, Oregon Section Chairman; Glenn Stanton, National President of A.I.A., and Edward Rambusch, guest at the Pacific Northwest Regional Conference, inspect a copy of the *I.E.S. Lighting Handbook* in front of the Publications display.

The Charter which was presented to the new Student Chapter at Oregon State College is here held by Dr. Howard Hall, Optometrist, Seattle, and Hal Semmens of A.I.A. in Vancouver while C. M. Cutler, General Electric Co., looks on.

In the meantime the ladies, under guidance of Mrs. Anne Ogden, Home Economist of Portland General Electric Company, were enjoying a local "Hostess House" radio broadcast. This well-planned program served as an encouragement for members attending future conferences to bring their wives with them.

The final session got under way with W. A. Newman of the Inland Empire Chapter as Chairman. A. F. Pongracz of the Western Pine Association, Downey, California, spoke on an interesting problem of lighting a lumber grader's table. This job was unique in that it required a different application of lighting principles to make the job of grading most accurate. Robert Thallon, engineer with Fluorescent Fixtures of California, San Francisco, next spoke on "A Year's Experience with Classroom Daylighting."

Chester W. Jarrett, Illumination Engineer of Portland General Electric Co., Portland, Oregon, presented a school lighting demonstration utilizing his scale model classroom. It has removable walls, floors, ceilings, furniture and fixtures and requires a crew of scene shifters. With it he is able to demonstrate stages of lighting and decorating the entire classroom environment. Through the use of a battery of photo-electric cells each calibrated to a specific spot in the room and a projection light meter, Jarrett demonstrated how effective the various treatments are and how to promote a coordinated lighting program.

The conference was topped off Friday evening by a special tours program arranged by C. H. Lundell, Utilities Engineer, City of Portland. The "Three-in-One" tour consisted of a visit to "The Biggest Log Cabin in the World," a recently renovated and illuminated forestry products exhibit; the General Electric Lamp Department offices and the Portland General Electric Street Lighting Laboratory.

Credit for excellent organization and coordination of the various committees goes to W. E. Potter, General Electric Lamp Division, Portland, Oregon and Jerry Collins, Portland General Electric Company, Chairman and Co-Chairman respectively. Mike Henkel of Wakefield Brass was responsible for the technical program; Frank Reis, Pacific Power and Light Company, budget; Jim Buman, Pacific Power and Light Company, publicity; E. R. Fletcher, Portland General Electric, attendance; T. W. Fitch, Portland General Electric Co., hotel; M. S. Prestwood, Portland General Electric Co., registration and reception; Arno Gish, Pacific Power and Light Company, banquet; John Bond, Portland General Electric Co., properties; Anne Ogden, Portland General Electric Co., ladies' entertainment; and C. H. Lundell, City of Portland, tours.

Home Lighting Workshop Given in San Francisco

For the first time on the West Coast, a complete course in home lighting was given, June 15-19 in San Francisco, through the combined sponsorship of the Northern California Section, I.E.S., the San Francisco State College and the Northern California Electrical Bureau. The course was approved for one unit of upper division college credit through San Francisco State College. Meetings were held in the Pacific Gas and Electric Co. auditorium.

The course was designed to meet the interests and needs of homemaking teachers, science teachers, lighting and color consultants and interior designers. Principal speakers were Myrtle Fahsbender, Director of Residential Lighting, Westinghouse Electric Corp., and Kaye Leighton, Residence Lighting Specialist, General Electric Co. Other lecturers were W. T. Kennedy, Kennedy Electric Co.; Paul Schmidt, General Electric Co.; and John Walsh, Pacific Gas and Electric Co.

The program which was illustrated with color slides, movies, demonstrations or exhibits, was as follows:

June 15

The Language of Lighting — Kaye Leighton.
Adequate Wiring for Good Home Lighting — W. T. Kennedy.
Light Sources for the Home — Paul Schmidt.

June 16

Light and Color — John Walsh.
Table, Floor and Wall Lamps—Kaye Leighton.
Solutions for Specific Lighting Problems — Myrtle Fahsbender and Kaye Leighton.

June 17

Modernizing Existing Home Lighting—Myrtle Fahsbender.
New Styles in Lighting Fixtures—Kaye Leighton.
Lighting the Kitchen and Home Laundry — Myrtle Fahsbender.

June 18

Architectural and Built-In Lighting — Myrtle Fahsbender and Kaye Leighton.
Modern Lighting for Traditional Interiors — Myrtle Fahsbender.
Bright Future — Color movie.

June 19

Lighting for Christmas, Garden Lighting, Lighting for Interior Decorative Effects — Kaye Leighton and Myrtle Fahsbender.
Better than Kings — Color movie.
Discussion of Materials Available for Use in Schools.
Question Period and Summary.

Banquet at the South Pacific Coast Regional Conference. Insert, right, shows President Strong at the podium.

Southern California Host To Outstanding Regional Conference

For many I.E.S. members on the west coast, in both coastal Regions, the annual Regional Conference is The Convention. As well it might be. The meetings are thoroughly organized, well attended, technically valuable, and fun. No exception was the two-day conference of the I.E.S. South Pacific Coast Region, held April 9 and 10 at the Edison Auditorium, Los Angeles. Some 240 members and guests attended.

Some indication of its importance locally is the wide publicity attending it, in Los Angeles papers, and by radio broadcast. All sessions were attended by the press, and a number of speakers were interviewed. The entire meeting was considered good, hot copy. With a press campaign now underway in California, for modern highway systems, the several papers on street and highway lighting were of particular interest.

Technical Program

Of convention proportions and with excellent organization, the papers program at the South Pacific Coast Conference presented some six sessions featuring top speakers. After each session, the speakers formed a panel for open forum discussion, a most stimulating feature.

Presiding at the morning session April 9 was Roy E. Dahlin, Chairman of the host section, Southern California. Robert W. Thunen, Chairman of the Northern California Section, presided Thursday afternoon; Dan Coyle, member of the Mother Lode Chapter, directed Friday morning's session April 10; and William Addison, San Jose Chapter's Chairman, took the closing afternoon.

First speaker was W. B. Gero of Westinghouse, Bloomfield, N. J., who discussed Mercury Vapor Street Lighting. Color corrected mercury lamps were demonstrated, and fluorescent street lighting also discussed.

A broad picture of street lighting, and recommended practice for it, was given by E. B. Karns of Westinghouse and C. H. Rex of General Electric, who presented phases of the new American Standard Practice for Street and Highway Lighting, as well as particular street lighting problems.

C. M. Cutler of General Electric, Nela Park, gave an unusually interesting demonstration-lecture on new developments in light sources.

H. U. Hjermstad of Sola Electric Co., Chicago, discussed wiring diagrams of many ballasts now in use, and discussed future trends in ballast development.

Fixture and lamp testing was discussed by Professor D. M. Finch, University of California, concerned primarily with reasons for fixture testing.

Papers presented Friday, April 10, included:

Modern Commercial Lighting, by Paul Schmidt, General Electric Oakland office. Mr. Schmidt showed recent colored slides of the new G.E. Supply office and warehouse, which with the various lighting systems installed, serves also as a demonstration area.

Creating a Selling Environment, by C. M. Cutler, included many new store lighting techniques and devices.

Better Lighting Through Better Coordination was a five-man panel discussion representing related fields. Participating in this very stimulating program were:

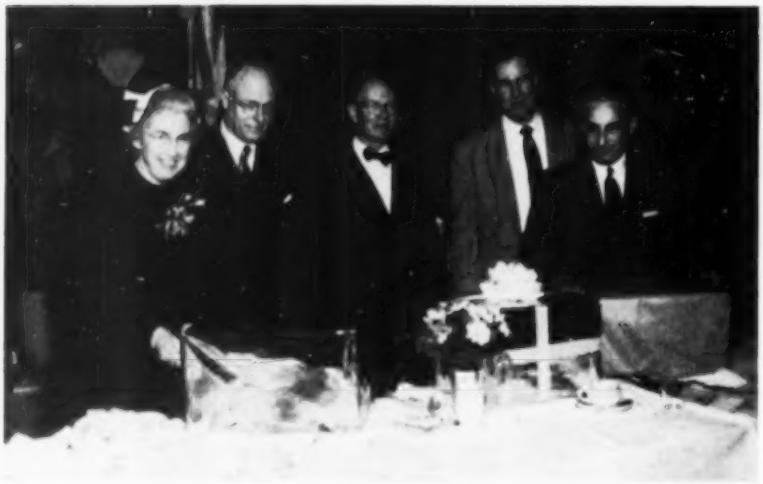
1. Architect — A. B. Gallion, Dean, U.S.C. School of Architecture.
2. Engineer — F. K. Sampson, Electrical Engineer.
3. Contractor — Julian Davis, N.E.C.A. contractor.
4. Manufacturer — Carl Martin, Benjamin Electric Mfg. Co., San Francisco, Calif.
5. Utility — O. K. Buck, manager of Commercial Dept., of Los Angeles Dept. of Water and Power.

Residential Lighting was next on the program, discussed by A. O. Trotenhuis, Moe Lighting Co., Los Angeles.

Fixture Design for Public Buildings was an especially interesting demonstration and talk by Edward Rambusch, of Rambusch Lighting Co., New York City.

My Most Interesting Lighting Job

Winding up the papers program was the presentation ceremony for the Region's contest for "My Most Interesting Lighting Job." Winning check for $25.00 was presented by Leonard A. Hobbs, Re-



At the President's Banquet, April 9, Mrs. E. M. Strong, Regional V-P Leonard Hobbs, Conference Chairman Ted Shepherd, Southern California Section Chairman Roy Dahlin and President Strong regard with approval some nicely wrapped packages.

gional Vice-President, to Merle Humber, Sunbeam Lighting Co., Northern California Section's entry, whose installation in the San Francisco Broadway Tunnel, took first prize. Second place winner was Oscar Meissner, for Southern California Section, who presented a unique system of lighting a drafting area with directional lighting on a herringbone pattern. Mr. Humber's entry will represent the Region at the New York finals.

PRESIDENT STRONG ATTENDS

Guest of honor at the conference was I.E.S. National President, Professor E. M. Strong, who also addressed the group during the banquet in his honor Thursday evening. Prof. Strong also held a number of press conferences, and was widely quoted in Los Angeles papers.

Great credit is due to a number of hard working men for the smooth operation of this conference. In particular: Leonard H. Hobbs, Regional V-P; T. H. Shepherd, Conference Chairman; Oscar W. Meissner, Conference Co-Chairman; Roy E. Dahlin, So. Calif. Section Chairman; R. W. Thunen, No. Calif. Section Chairman; Wm. Addison, San Jose Chapter Chairman; Andrew Louargand, Mother Lode Chapter Chairman.

CONFERENCE COMMITTEES

R. E. Jones, Papers and Program
Earl F. Larson, Hotel
Merle A. Potter, Entertainment and Reception
Del Reynolds, Space Arrangements and Program Properties
Roy H. Kreyser, Publicity
F. Jack Rohring, Attendance
F. Edwin Blair, Finance
Donald W. Prideaux, Budget
Wm. P. (Teddy) Bear, Registration

Local Representatives

Carlton M. Thompson, San Diego
Harry Lobson, Santa Barbara
James W. Dickson, Santa Ana
Tom Durfee, Oxnard
Engle F. Randolph, Long Beach
Norman A. Schiewe, Vallejo
Jack Hammond, Fresno

I.E.S. National Technical Conferences

September 14-17, 1953 — Hotel Commodore, New York
September 12-16, 1954 — Chalfonte-Haddon Hall, Atlantic City
September 12-16, 1955 — Statler Hotel, Cleveland
September 16-21, 1956 — Statler Hotel, Boston.

TV Program Conducted By Cleveland Section Members

Members of the Cleveland Section, I.E.S., participated in one of a series of television programs over WNBK, "Adventures in Engineering," May 3, when their program "Engineering for Better Vision," was produced. The series of programs, sponsored by the 46 member societies of the Cleveland Technical Societies Council, is aimed at high school and junior high school students with the purpose of interesting them in engineering careers.

The I.E.S. program, starring Merle Keck, Westinghouse, and Alston Rogers, General Electric, was a demonstration to Program Moderator Paul Bedford and Student Guest Edward Schuman, touching on the following topics of illumination: incandescent, fluorescent and mercury vapor lamps; principles of light control and their application; light measurement; factors in seeing and visibility; the importance of quality lighting; interior lighting; and the lighting at the Cleveland Stadium. The program concluded with a brief question period.

Credit for the program, in addition to its stars, is due to John J. Neidhart who, as I.E.S. representative to the C.T.S.C. Vocational Guidance Committee, lined up the talent and helped to organize the show; WNBK Program Director George Cyr, and Paul Bedford, host and moderator.

The series, started last fall on a weekly basis, will be resumed after the summer vacation.

Optical Society Conference Presents Papers on Illumination

The Spring Conference of the Optical Society of America, held March 19 through 21, at the Hotel Statler in New York City, featured at its March 20 sessions three outstanding illumination papers. A large attendance of lighting people at this session heard the following invited papers:

"Photometric Units" by Ray P. Teele, National Bureau of Standards.

"Applied Photometry with Special Reference to the Gonio Types" by William F. Little, Electrical Testing Laboratories, Inc.

"Physical Methods of Photometry" by W. E. Knowles Middleton, National Research Council of Canada.

Some 86 papers were presented in the program of sessions at the three day conference. Abstracts of the Optical Society's papers may be obtained from Dr. A. C. Hardy, Room 8203, Massachusetts Institute of Technology, Cambridge, Mass.

Southwestern Regional Conference Host to Council in Dallas

An early taste of June weather was afforded northern Council members — at the Regional Conference in Dallas April 13. In return, Texans got their first glimpse of the national body in action, when Council met there just prior to the conference at the Baker Hotel, April 13-15. Council assembly so far from headquarters was something of an experiment. A successful experiment, it was decided, worth repeating next Spring — probably in New Orleans.

The attendance statistics for the conference are a significant part of the success story. Every section of the Region was represented; something like 139 visitors, quite aside from I.E.S. members, were attracted to it; fifteen national officers and headquarters staff were present for the entire conference; classification of registrants was from every branch of the industry — architects, contractors, engineers and educators. Total attendance was 322.

Another feature of its success was definitely the technical program. Top speakers, both local and imported, were featured (see program listing). Sessions were packed — a tribute to the excellence of the program offered.

In addition to some ten interesting papers, three addresses were given during the conference, of very particular significance to I.E.S. members. Two were by I.E.S. President E. M. Strong, one by the Region's Vice-President W. E. Folsom. President Strong addressed 102 men and women attending a luncheon April 13, sponsored jointly by the Southwestern Region of I.E.S. and the Electric Club of Dallas, a most inspiring address. During the morning session on April 14, President Strong spoke again, this time telling I.E.S. members "How the Illuminating Engineering Society Serves," and demonstrating with slides such pertinent Society data as membership growth, Society services, headquarters set-up, etc. Professor Strong's talk on Society organization and service is rather an innovation for presidential addresses which has been received with very considerable interest at all of the regional meetings he has attended.

W. E. Folsom's "Report of the Regional Vice-President" was also a new approach in V-P service to members. The 300-odd members present were particularly interested in his report of the Region's activities during the past year, as well as the history of the Region and many sidelights on Society and Regional functions included in his address.

M. M. I. L. J.

This was Southwestern's first year for the now national and popular contest "My Most Interesting Lighting Job." It was conducted in veteran style, however, with three of the Region's sections participating. Chairman in charge of the contest was V. J. Graham, who presented winning checks to:

First Prize — E. J. Whitlow, McClure Electric Co., Dallas. "Lighting a TV Tower."

Second Prize — H. G. Hrivnatz, Houston Lighting and Power Co., "Lighting an Underpass."

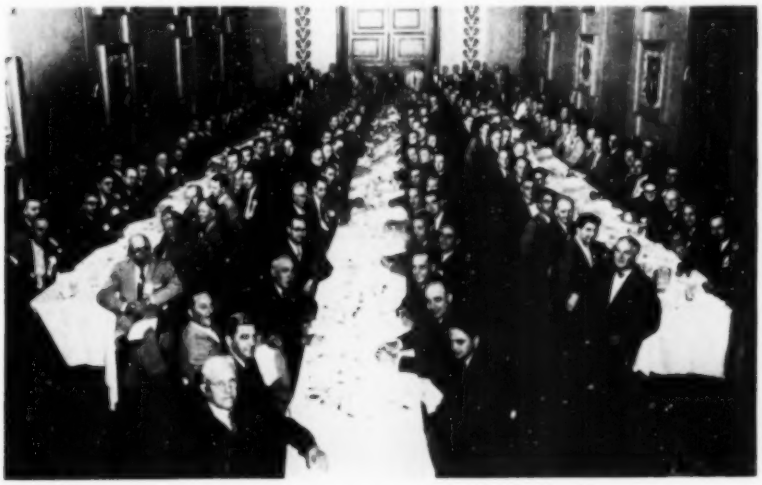
Attendance in Dallas

Alamo Chapter	14
Oklahoma Chapter	17
San Jacinto Section	24
Southwestern Section	99
Non Regional Members	29
Non Member Visitors	139
Total Attendance	322

Outgoing and incoming Vice-Presidents of the Southwestern Region, W. E. Folsom and M. J. Myers.

President Strong swinging through a , set at the square dance.

Dex Hinckley, Executive Secretary from headquarters, and Larry Paist, Midwestern Regional V-P at square dance.



Joint luncheon meeting with the Electric Club of Dallas was a feature of the Southwestern Regional Conference April 13. I.E.S. President Strong was main speaker.

Packed sessions at the Southwestern Regional Conference in Dallas April 13-15 were a tribute to the excellence of the technical program presented there.

Walter Sturrock, Past-President, and Mrs. V. J. Graham of Dallas.

Third Prize — John L. Healy, Leader Electric Co., Dallas. "Relighting a Bank."

Mr. Whitlow's entry qualifies for the finals in this contest, to be held in New York in September, at the National Technical Conference.

ENTERTAINMENT

The regional "banquet" in Dallas was southwestern style — in nature and size. Dinner was a ranch style barbecue with a chow line, and very superior chow. Barbecued beef, ham, beans, spaghetti were piled high and disappeared fast. So did a lot of good hot coffee. The party following was predominately a square dance, entertaining to both participants and the side lines.

Three big Texas hats were bestowed with appropriate ceremony during the party. President Strong, Cash Crouch and Dex Hinckley were all so honored, P. M. Rutherford and W. T. Kimery making the presentations.

TECHNICAL PROGRAM

A complete listing of the program presented in Dallas is as follows:

Monday, April 13

National Council Meeting — English Room. Section and Chapter Officers were invited as spectators and were urged to attend the Council Meeting.

Luncheon Session — Texas Room.
Joint meeting with the Electric Club of Dallas — Speaker, President E. M. Strong.

Technical Session
Home Service Auditorium
Dallas Power & Light Bldg.
Chairman — W. T. Kimery, Dallas Power & Light Co.

Trends in Residential Lighting — Edith L. Buchholtz, Home Lighting Consultant, Westinghouse Electric Corp., Bloomfield, N. J.

My Most Interesting Lighting Job Contest — V. J. Graham, General Electric Co., Dallas, Texas. Presentation and judging of Chapter and Section Contest Winners.

P. M. Rutherford, left, makes President Strong a "citizen of Texas."

Monday Evening
Dinner Dance — Southwestern Style
Tuesday, April 14
Texas Room — Baker Hotel
Chairman — Harold F. Miller, Sylvania Electric Products Inc., Tulsa, Okla.

Report of Regional Vice-President — W. E. Folsom, Regional Vice-President.

How the Illuminating Engineering Society Serves — Prof. E. M. Strong, President, Illuminating Engineering Society.

A Bushel of Light — C. L. Crouch, Technical Director, Illuminating Engineering Society.

Local Activities Luncheon — English Room. W. E. Folsom, Presiding.

Technical Session
Texas Room — Baker Hotel
Chairman — E. S. Richardson, Electrical Distributing Co., San Antonio, Texas

Visual Learning and Classroom Brightness — Dr. D. B. Harmon, Educational Consultant, Austin, Texas.

Ballasts and Circuit Control Devices — Wm. C. Anderson, Chief Engineer, Jefferson Electric Co., Bellwood, Ill.

Lighting Progress Report—Ted Sargent, Sylvania Electric Products, Inc., Salem, Mass.

Mrs. W. E. Folsom and Dr. and Mrs. D. B. Harmon of Austin, Texas.

Wednesday, April 15
Technical Session
Texas Room — Baker Hotel
Chairman — J. D. Weissner

Floodlighting Design and Applications, Benjamin S. Benson, Jr., Benjamin Electric Mfg. Co., Des Plaines, Ill.

Modern Industrial Lighting, by Kirk Reid (for E. A. Linsday), General Electric Co., Cleveland, Ohio.

Trends in Lighting Fixture Design, William Kahler, Westinghouse Electric Corp., Cleveland, Ohio.

IDEAS WORTH STEALING

Future Regional Conferences might find the following practices as useful as did the Southwestern Region:

1. The Regional Vice-President's report on the history and present activities of the Region plus an inspirational and informing talk on I.E.S.
2. The President's address on Society facts, figures and functions.
3. A prominent display of I.E.S. publications with active sales efforts for same.

(Continued on page 15A)

here's real...
PROOF OF PREFERENCE

1097
SILVRAY
SCHOOL LIGHTING
INSTALLATIONS
MADE IN 1952

Typical classroom at the Horace Mann Junior H. S. using SILVRAY 1500 LINE incandescent fixtures

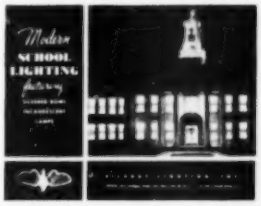
and here are the reasons why . . .

- **EFFICIENCY:**
  Certified initial efficiencies of 85 to 90% which are restored with each new silvered bowl lamp
- **APPEARANCE:**
  Simplicity and gracefulness of line, judged ideal for classrooms, auditoriums, lecture halls, etc.
- **MAINTENANCE:**
  Absolute minimum as dust, dirt or missles cannot collect on fixture
- **RELAMPING:**
  Lamps replaced from floor in matter of seconds without handling fixture
- **PATENTED HANGER:**
  Provides vertical alignment on sloping ceilings or on clerestory monitors
- **FLEXIBILITY:**
  150 to 1000 W silvered-bowl incandescent lamps in 3 or 4 ring units to achieve any desired footcandle level

These are just a few reasons why the SUPER 1500 line indirect luminaire is the preferred choice of school architects and administrators throughout the nation.

SILVRAY
Lighting up America's Schools

SEND FOR THIS BOOKLET OF COMPLETE DETAILS



Modern
SCHOOL LIGHTING
featuring
SILVERED-BOWL
INCANDESCENT LAMPS

This completely detailed and illustrated 16 page booklet provides up-to-the-minute facts on correct school lighting and how the 1500 Line is an important factor in the new concept of school lighting. It's free . . . just fill-in and mail this coupon.

SILVRAY Lighting, Inc.,
104 West Main St., Bound Brook, N. J.

Gentlemen:
Please send me further information
on the Silvray SUPER 1500 unit.

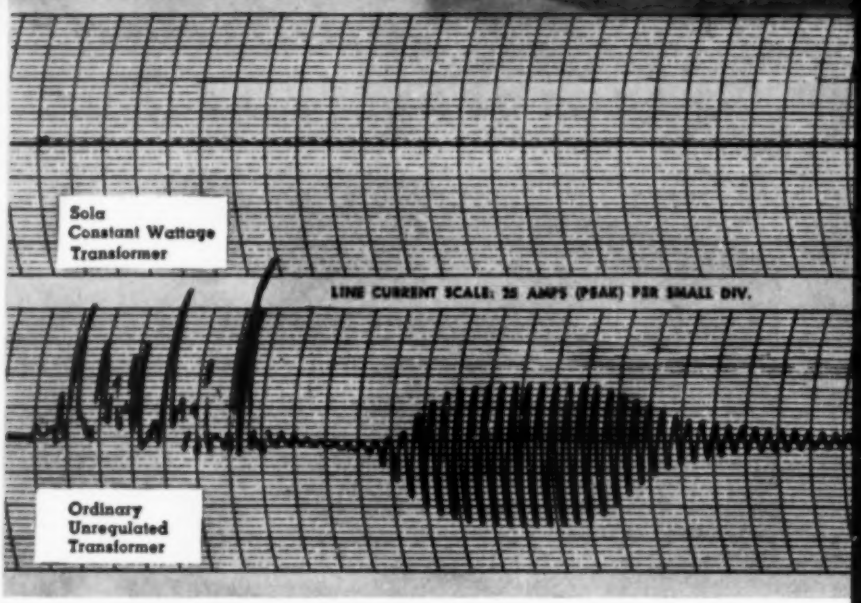
Name _____

Firm _____ Title _____

Address _____

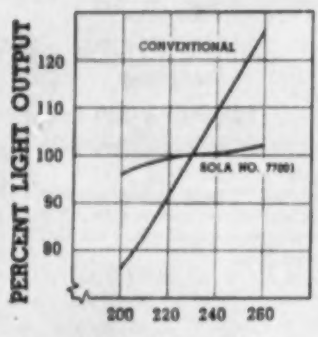
City _____ Zone _____ State _____

REGULATED INDOOR BALLAST for Type H1 Mercury Vapor Lamps. Unit has ½" and ¾" knockouts, large access panels to roomy wiring compartments, and is designed for wall or ceiling mounting. Outdoor constant wattage transformers for industrial and commercial floodlighting and premium quality conventional indoor units are also available.



NEGLIGIBLE STARTING CURRENT SURGE of Sola Constant Wattage Transformer is illustrated by the top tracing. The bottom tracing illustrates the heavy starting current surge of the ordinary unregulated transformer. Regulated current characteristic reduces installation costs by permitting use of smaller capacity circuit breakers, wiring and other equipment. On incandescent-to-mercury-vapor conversions, low starting surge current permits maximum use of existing wiring and switching gear.

Mercury Vapor Lamps Operate At *FULL RATED LIGHT OUTPUT* with Sola CONSTANT WATTAGE Transformers



LIGHT OUTPUT REGULATION of EH-1 Mercury Vapor Lamp with Sola Constant Wattage Transformer No. 77001 and a conventional autotransformer type. Regulation under high voltage conditions extends lamp life by restricting lamp operations within rated values. Nominal light output is maintained under low voltage conditions.

You get all the lumens you pay for when your mercury vapor lamps operate from Sola Constant Wattage Transformers. These regulated ballasts will continuously and automatically supply constant wattage within ±2% regardless of line voltage fluctuations as great as ±13%.

In addition to the maintenance of light output, they have the following advantages over the ordinary unregulated type:

- **Eliminates any need for primary voltage taps.**
- **Assures positive starting within the primary voltage (±13%) range.**
- **Reduces installation cost because of negligible (5 amps) starting current surge.**
- **Virtually eliminates lamp outages due to line voltage drops.**
- **Long transformer life, since the ballast is self-protecting and actually runs cooler (approx. 34°C) on open circuit.**

WRITE FOR BULLETIN C-MV-166 FOR COMPLETE DATA

Regulated Outdoor

Regulated Indoor

Conventional Indoor

SOLA *Mercury Vapor Lamp* **TRANSFORMERS**

Transformers for: Constant Voltage • Fluorescent Lighting • Cold Cathode Lighting • Mercury Vapor Lighting • Luminous Tube Signs
SOLA ELECTRIC CO., 4633 W. 16th Street, Chicago 50 Illinois. Bishop 2-1414 • NEW YORK 35: 103 E. 125th St., TRafalgar 6-6464
PHILADELPHIA: Commercial Trust Bldg., Rittenhouse 6-4988 • BOSTON: 272 Centre St., Newton 58, Mass., Bigelow 4-3354
CLEVELAND 15: 1836 Euclid Ave., PRospect 1-6465 • KANSAS CITY 2, MO.: 406 W. 34th St., Jefferson 4382 • Representatives in Principal Cities

Bob Wilson and his Outlaw Band.

(*Continued from page* 12A)

4. Wide dissemination of I.E.S. brochures and membership information.
5. A Local Activities luncheon (44 attending) with reports from Local Representatives as well as Section and Chapter officers.
6. Organized local effort for future Conference sites. Bids were presented at the Local Activities luncheon, backed by letters from the mayor and plenty of literature. Result—Houston in 1954; San Antonio in 1955.

Who's Who

Good Committee organization was definitely evident at the Dallas meeting. The convention-size crowd was handled effortlessly, evidence in itself of much hard work beforehand. Those contributing to this were:

General Conference Chairmen

H. R. Heitzman — P. M. Rutherford

Finance Committee

W. A. Kimery, *Chairman*
E. C. Ober — Dale H. Watt
Floyd A. Covington, Jr.

Papers and Program Committee

John G. Felton, *Chairman*
Bernice B. Davis — N. O. Reed
John B. Deck, Jr. — Wynne Snoots
Robert G. Smith

Entertainment Committee

W. H. McAdams, *Chairman*
C. M. Cockrell — H. B. Sudekum
James T. Meletio

Attendance Committee

W. J. Childers, *Chairman*
Hiram O. West — Joe Burns
Henry Albrecht

Arrangements Committee

Fred A. Brewer — V. J. Graham

Reception and Registration Committee

W. A. Kimery, *Chairman*
Miss Ruth Patterson — Don Gallagher
L. J. Pagnini

Transportation Committee

J. A. Reeves

Publicity Committee

James T. Meletio, *Chairman*
E. E. Gruver — Hiram O. West

Ladies Reception Committee

Mrs. F. J. Peabody, *Chairman*
Mrs. V. J. Graham — Mrs. W. T. Kimery
Mrs. W. E. Folsom — Mrs. W. H. McAdams

Some of the companies which the French group toured were:

Ruby Philite Corp., Long Island City, N. Y.
Lightolier, Inc., Jersey City, N. J.
Century Lighting Co., New York, N. Y.
New York Fluorescent Mfg. Co., New York, N. Y.
General Electric Co., Cleveland, Ohio.
F. W. Wakefield Brass Co., Vermilion, Ohio.
Day Brite Lighting Inc., St. Louis, Mo.
Benjamin Electric Mfg. Co., Des Plaines, Ill.
Electro Silv-A-King Corp., Chicago, Ill.
Mitchell Mfg. Co., Chicago, Ill.
Luminator, Inc., Chicago, Ill.
Frink Corp., Long Island City, N. Y.
General Lighting Co., Brooklyn, N. Y.
Amplex Corp., Brooklyn, N. Y.

While in Washington, the study group visited the Congress of Industrial Organizations and the American Federation of Labor International Representatives.

Lighting and Color Are Topics At Occupational Vision Congress

The Fifth Occupational Vision Congress in Atlanta, Georgia was held at the Georgia Institute of Technology May 7 and 8. The Georgia Section of I.E.S., which has taken an active part in this Congress since its beginning four years ago, was co-sponsor with the following groups:

Associated Industries of Georgia.
Georgia Association of Industrial Nurses.
Georgia Optometric Association.
Georgia Society of Ophthalmology and Otolaryngology.
Occupational Health Division, Georgia Department of Public Health.
Southern Occupational Vision Council.

The program which covered the many facets of industrial vision problems, featured two lectures on lighting. John J. Neidhart, Westinghouse Electric Corp., discussed "Lighting and Color" in the morning session, May 8; W. N. Cox, Jr., Professor at the School of Industrial Engineering, Georgia Institute of Technology, and Jack E. Murrah, past chairman of the I.E.S. Georgia Section, spoke on "Safety, Light, and Color."

Four Prizes Awarded in Philadelphia Student Contest

The prize problem in this year's Student Competition sponsored by the Philadelphia Section was how to light a home with "picture" windows to avoid the appearance of a black mirror effect at night. The four winners, who each received $30 prize money, were

Martin Price, University of Pennsylvania.
Charles Sharp, Drexel Institute of Technology.
William Stuber, University of Pennsylvania.
George Felbin, University of Pennsylvania.

All of the 103 entries were pre-judged by two engineers and given lighting ratings. The jury which then made the awards consisted of two practicing archi-

(*Continued on page* 19A)

Construction Industry Outlook Promising for Next Few Years

The construction industry may reverse historical precedent in the next few years by proving that a recession need not always follow peak industrial activity caused by war and preparation for war, according to *Engineering News-Record*, a McGraw-Hill publication. Never before have conditions been more promising to achieve such a goal, the magazine says.

The most important reason for construction optimism is the accumulated backlog of specific construction projects that have been announced for the future, totaling $69 billion. In addition, construction has experienced eight years of steadily rising business, placing it at the top of the longest and biggest boom in its history, the magazine points out.

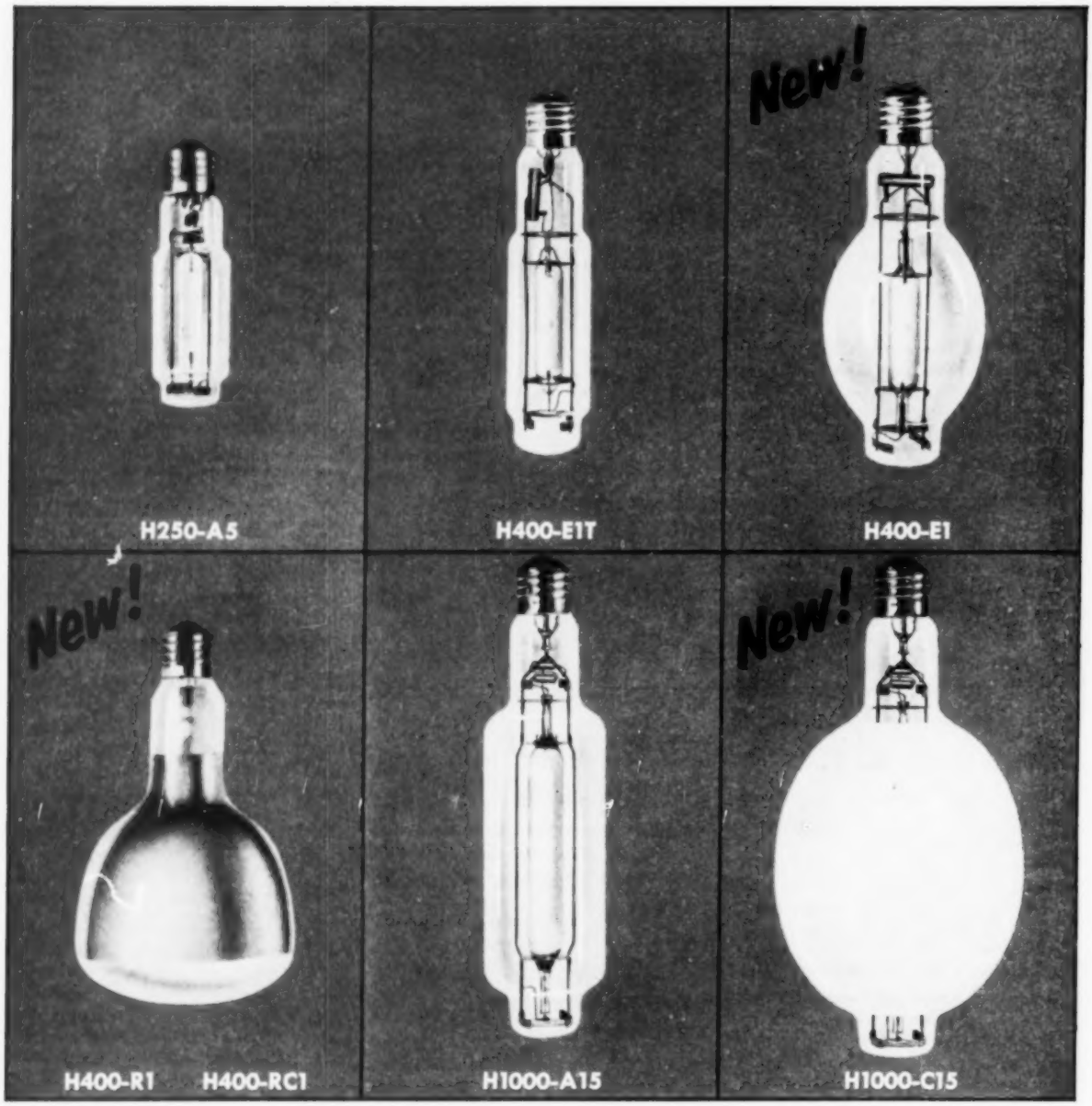
The most powerful force in this recent expansion has been defense spending by the federal government, but there are enough favorable factors in the business picture to assure against deep digs in business and to support a sizable future volume of construction when this spending is reduced.

Despite these good conditions, construction prosperity is not a certainty. There will be economic and political obstacles that only hard work and intelligent planning can overcome, the magazine warns.

French Technical Study Group Visits U. S. Lighting Companies

Under the auspices of the Productivity and Technical Assistance Division of the Mutual Security Agency, a technical study group from France visited several manufacturers of lighting equipment from May 1 to June 2, to observe and study modern United States production methods and improvements which will aid in the defense effort of the Western European countries.

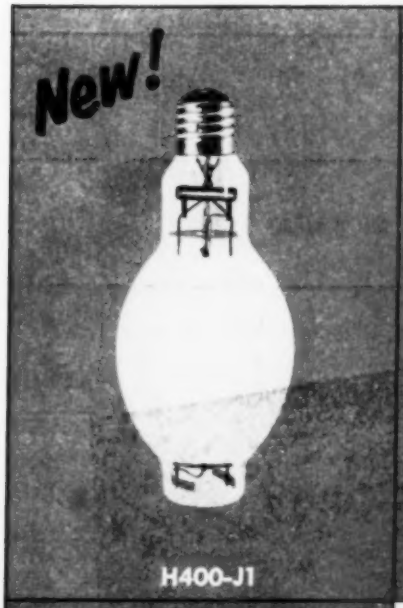
There's a General every mercury



GENERAL ELECTRIC'S COMPLETE LINE offers you the right mercury lamp for general lighting applications in factories, for street lighting and outdoor flood-lighting. These highly efficient, long lasting lamps are the answer to lighting problems that require maximum light output and easy maintenance.

For more information, call your nearest G-E lamp supplier or write General Electric, Department 166-IE-6, Nela Park, Cleveland 12, Ohio.

Electric lamp for lighting need!



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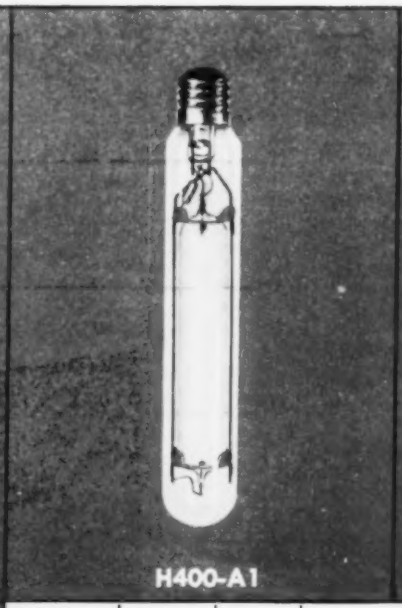
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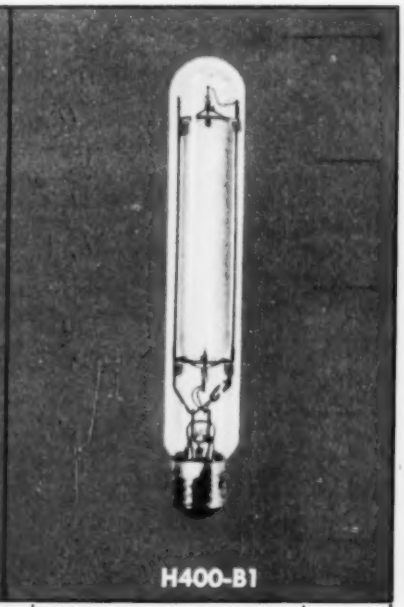
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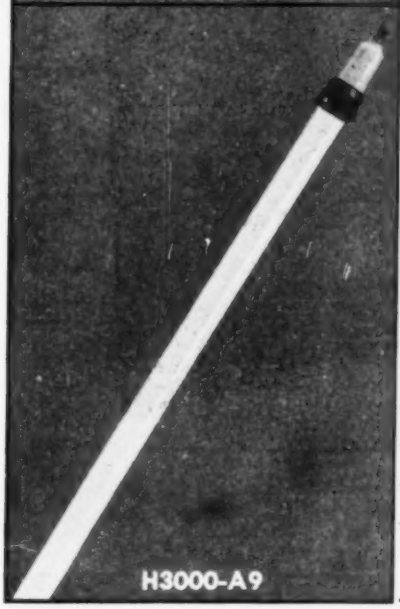
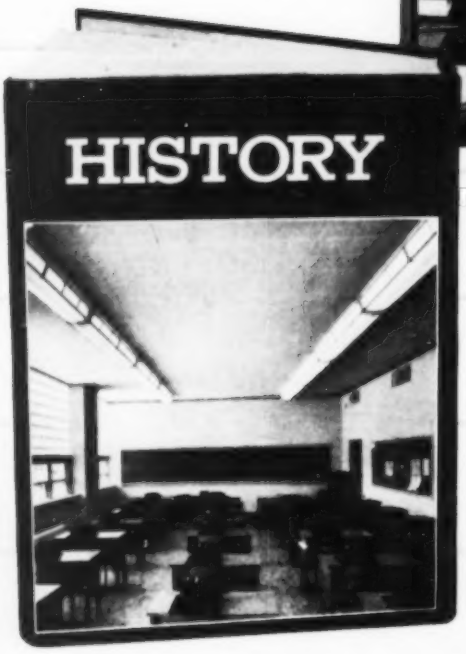

H3000-A9

Ordering No.	Approx. Watts	Bulb	Base	Description	Approx. Lumens (100 Hours)
H250-A5	250	T-18	Mog. ①	General and Street Lighting	11,000
H400-E1T	400	T-20	Mog.	General and Street Lighting	19,000
H400-E1	400	BT-37	Mog.	General & St. Ltg.; Black Light	19,000
H400-J1	400	BT-37	Mog.	General and Street Lighting ②	17,000
H400-A1	400	T-16	Mog.	General and Street Lighting	15,000
H400-B1	400	T-16	Mog.	General and Street Lighting (Burn within 10° of vertical, base down)	15,000
H400-R1	400	R-52	Mog.	Reflector, High Mounting I.F.	16,000
H400-RC1	400	R-52	Mog.	Reflector, High Mounting ②	12,300
H1000-A15	1000	T-28	Mog.	High Mounting Industrial Ltg.	52,000
H1000-C15	1000	BT-56	Mog.	High Mounting Industrial Ltg. ②	46,000
H3000-A9	3000	T-9½	S.C. Term.	High Mounting Industrial Ltg.	132,000

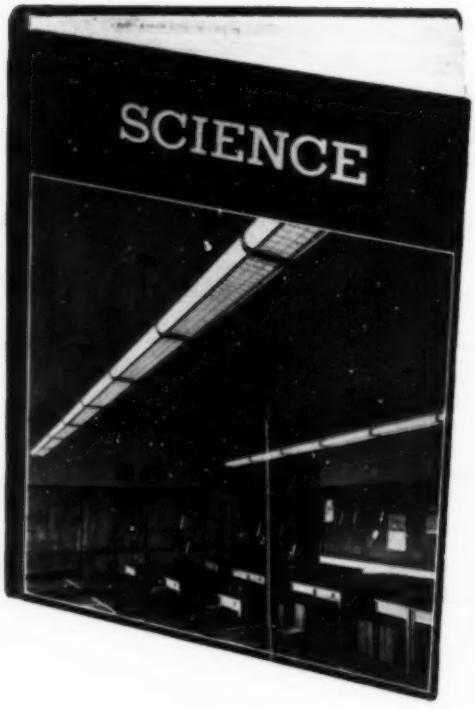
① This and all other mogul bases are mechanically attached instead of cemented to prevent loosening.
② Color improved—approximates color effect of equal wattage mixture of filament and regular mercury lighting.

You can put your confidence in—

GENERAL ELECTRIC



Today's test is in better school lighting



Independent surveys, such as those by the Illuminating Engineering Society and the American Standards Association, show that better school lighting contributes to higher average grades, faster reading habits, more correct posture and general visual comfort. Many Sunbeam installations prove that better school lighting has been achieved through the coordinated efforts of architects and our illuminating engineers. Typical installations are at Tucson, Ariz. (above) with #1210-96 units and at Houston, Tex. with #1500-96. See our catalog of school fixtures in the 1952-53 edition of "The American School and University."

SUNBEAM visionaire LIGHTING COMPANY

SUNBEAM LIGHTING COMPANY

777 EAST 14TH PLACE • LOS ANGELES 21, CALIF.

(Continued from page 15A)

tects, Louis I. Kahn and Oscar Stonorov; two professors of architecture, Dean G. H. Perkins of U. of P. and Arnold Mogensen of Drexel; and two I.E.S. members, Ralph Enghouser and George Shoemaker.

The prizes were awarded at the April meeting of the Philadelphia Section at which the winners showed their drawings and described their designs to the audience.

Architectural Students Win Awards In California Competition

Presentation of prizes in the Architectural Students Lighting Design Competition for 1953 was a highlight of the annual joint dinner meeting of the Southern California Section of I.E.S. and the American Institute of Architects. First, second and third place winners were Donald R. Betzsold, Richard T. Olerich and D. W. Drazan; runners up, Frank O. Goldberg, Benjamin P. Urmston and Paul C. Hanson. Presentation of prizes was made by Section Chairman Roy E. Dahlin.

Members of the jury who judged the entries were, from A.I.A.: Eugene Choy, Louis Armet, Eldon Davis and Romeo Rodriques; from I.E.S.: Lou Black, C. M. Cutler, Dan Solomon and Clayton Gibbs.

N. Y. Residence Lighting Forum Sponsors Series of Meetings

The New York Residence Lighting Forum recently completed a series of four related meetings which aroused unusual interest, both among its members and persons in affiliated fields. The series began with the January meeting, which laid the foundation for the others by discussing the basic subject of "Light — Its Effects on Human Beings, Physiological and Psychological." The physiologist's viewpoint was represented by Dr. Gerald Fonda, Assistant Professor of Ophthalmology at the New York University Medical School, and the psychologist's by Mr. Charles R. Kelley, Assistant Professor of Psychology and Associate Director of the Division of Vision Research at North Carolina State College. Dr. Fonda outlined the organic effects of light on the eye, and the effect of illumination on visual acuity, while Mr. Kelley defined the present limits of knowledge resulting from psychological research on visual perception as influenced by illumination. Mr. Berlon Cooper, Eastern Editor of *Electrical Construction and Maintenance*, completed the program by presenting a bibliography of publications relating to the subject.

The February meeting, held in the Members' Penthouse of the Museum of Modern Art, was an informal symposium on "The Use of Light to Create Art." Under the stimulating chairmanship of Mr. Philip Johnson, Director of the Department of Architecture and Design of the Museum, a large number of architects, lighting designers, engineers, and specialists in related fields of art contributed to a discussion of the basic functions of natural and artificial light in buildings, and the ways in which light may be applied architecturally. Vigorous expression of various individual points of view made the program a thought provoking one. A recurrent theme was the appeal of the architects to the lighting engineers for lighting information and assistance in a form that they could put to practical use. Mr. Richard Kelly, lighting designer, gave a general introduction to the subject.

The third meeting in the series dealt with "Lighting in the Development House." This program took the form of a panel discussion with Mr. Douglas Haskell, Editorial Chairman of *House & Home*, as moderator, and five speakers well qualified to represent their respective interests: Mr. Frank Tufaro, President of the New York State Association of Home Builders, Miss Myrtle Fahsbender, Director of Residential Lighting for the Westinghouse Electric Corporation, Mr. John Callender of the Southwest Research Institute, Miss Gladys Miller, decorator and consultant, and Mr. Kenneth Welch, architect and store designer. Emphasis was laid on the need for, and the value of, better lighting than is provided in most development homes; at the same time the problems facing the builder, and the difficulties in the way of providing satisfactory lighting, were made clear. Members of the audience joined in another spirited discussion, and again a request was made, this time by the builders, for more lighting information and assistance. A special feature of the program was a report on a typical development house which had been relighted in accordance with recom-

(Continued on page 20A)

LIGHTING CALENDAR

Society Events

September 14-17, 1953—Illuminating Engineering Society, National Technical Conference, Commodore Hotel, New York, N. Y.

September 12-16, 1954—Illuminating Engineering Society, National Technical Conference, Chalfonte-Haddon Hall, Atlantic City, N. J.

Industry Events

June 8-10, 1953—National Association of Electrical Distributors, Pacific Zone, Huntington Hotel, Pasadena, Calif.

June 9-12, 1953—Store Modernization Institute, Fourth Annual Modernization Show, Madison Square Garden, New York, N. Y.

June 15-19, 1953—American Institute of Electrical Engineers, Summer General Meeting, Atlantic City, N. J.

June 22-26, 1953—Annual Convention of the American Society for Engineering Education, University of Florida, Gainesville, Fla.

June 28 - July 2, 1953—American Society of Mechanical Engineers, Semi-Annual Meeting, Statler Hotel, Los Angeles, Calif.

July 5-10, 1953—New York Lamp Show, Hotel New Yorker, New York, N. Y.

August 5-8, 1953—International Association of Electrical Leagues, 18th Conference, Fairmont Hotel, San Francisco, Calif.

September 1-4, 1953—American Institute of Electrical Engineers, Pacific General Meeting, Hotel Vancouver, Vancouver, B. C., Canada.

September 21-26, 1953—International Association of Electrical Inspectors, 25th Jubilee Meeting, Edgewater Beach Hotel, Chicago, Ill.

September 23-25, 1953—Canadian Electrical Manufacturers Association, Annual Meeting, General Brock Hotel, Niagara Falls, Ont.

October 5-9, 1953—Society of Motion Picture and Television Engineers, Semi-Annual Convention, Hotel Statler, New York, N. Y.

October 6-8, 1953—Fourth Industrial Electric Exposition, William Penn Hotel, Pittsburgh, Pa.

October 19-21, 1953—American Standards Association, 35th Annual Meeting, Waldorf-Astoria Hotel, New York, N. Y.

October 19-23, 1953—National Safety Council, 41st National Safety Congress & Exposition, Chicago, Ill.

November 2-6, 1953—American Institute of Electrical Engineers, Fall General Meeting, Muehlebach Hotel, Kansas City, Mo.

November 9-12, 1953—National Electrical Manufacturers Association, Haddon Hall Hotel, Atlantic City, N. J.

November 16-20, 1953—National Electrical Contractors Association, Miami Beach, Fla.

November 29 - December 4, 1953—The American Society of Mechanical Engineers, Annual Meeting, Statler Hotel, New York, N.Y.

January 18-22, 1954—American Institute of Electrical Engineers, Winter General Meeting, New York, N. Y.

March 8-11, 1954—National Electrical Manufacturers Association, Edgewater Beach Hotel, Chicago, Ill.

ONE of the meetings of the New York Residence Lighting Forum this year featured a panel discussion with the following members: l. to r., Moderator Richard Kelly, lighting consultant; Louis Kahn, Philadelphia architect; Harry McNary, Fischbach and Moore; Thomas Smith Kelly, lighting consultant and Harry Hebbeln, architect.

(Continued from page 19A)

mendations made by Miss Fahsbender and Mr. Richard Kelly. Before and after photographs were shown, as well as a display of the equipment utilized. The owner of the house was present to express his gratification with the new lighting facilities. A complete description of this project is published in the May issue of *House & Home*.

The April meeting, the final one of the series, was another panel discussion, entitled "New Problems of Light Created by Contemporary Architecture." Mr. Richard Kelly, lighting designer and engineer, acted as moderator and chairman, and posed the problems which were discussed by the other members of the panel: Mr. Louis Kahn and Mr. Henry Hebbeln, architects, Mr. Thomas Smith Kelly, lighting consultant, and Mr. Harry McNary, lighting engineer of Fischbach and Moore, electrical contractors. The discussion was concerned primarily with the lighting problems arising from the current trends in residential architecture toward large areas of glass, open planning, and multi-use of space. Among specific topics considered were: means of preventing troublesome reflections of light sources in glass at night; methods of exterior lighting, either to prevent the unattractive effect of blank black walls, or to make possible evening use of adjacent outdoor space; the handling of light, both natural and artificial, to avoid too great contrast in the daytime between highly illuminated areas near windows and interior areas; and differences between day and night orientation in the use of a room, which must be recognized and planned for. This program was a joint meeting of the Residence Lighting Forum and the New York Chapter of the American Institute of Architects, and was well attended by representatives of the architectural profession.

As a result of these meetings the Forum was invited to visit the famous all-glass house of Mr. Philip Johnson, and another interesting residence in New Canaan, Conn., and this trip was arranged as the May meeting. The Program Committee in charge of the meetings has consisted of: Mathew Veeck, Chairman, Berlon Cooper, Miss Elizabeth Kaufer, Richard Kelly, Miss Ruth Lieb, and Joseph Villani, working in cooperation with Miss Edith Buchholtz, Chairman of the Forum, and Miss Winonah Murphy, Secretary Treasurer.

Architectural Designs Invited By Churchman's Exposition

Architects are again being invited to submit designs for hanging in the "Hall of Church Designs" at the International Churchman's Exposition, in the Chicago Coliseum October 6 to 9, according to Joe Vancil, exposition manager. Thousands of building committees and ministers of all denominations are expected to be present at the International Church Buildings Forum, which will feature speakers on church lighting, in addition to other architectural and financial aspects of church building and remodeling.

Entry blanks for submitting designs can be secured from the International Churchman's Exposition, 19 South La Salle St., Chicago 3, Illinois.

3-D Photography and Depth Perception Explained

Three-D is at least 2,500 years old, according to an article which appears in the April-May issue of the *Journal of the American Optometric Association*.

Egyptian and Grecian works of art pre-dating the Christian era show full use of "interposition," which is still the most powerful of the many cues to perception of the third dimension in motion pictures, television, still photographs and paintings, Dr. T. R. Murroughs, author of the article, said.

He described interposition as "overlay of contours — nearer objects overlapping or cutting off parts of more distant objects to make them appear in the background," when depicted on flat surfaces.

(Continued on page 24A)

Submitted by Frank Carter, Westinghouse Electric Corp.

Installation: World Book Encyclopedia and Childcraft Field Enterprises, Inc., Educational Division, Merchandise Mart, Chicago 54, Illinois

Architect: Naess & Murphy, Chicago, Illinois

Fixture Manufacturer: Day Brite Lighting Company, St. Louis, Missouri

Electrical Contractor: White City Electric Company, Chicago, Illinois

Reflection factors

Ceiling, acoustical tile —80% (approx.)

Walls, various color tones —50% (approx.)

Floors, variegated —30% (approx.)

The *right* lightingware *accents* striking design

Nothing has more influence on the design of an office and the morale of its employees than the appearance and performance of lighting glassware.

Take, for example, the World Book Encyclopedia and Childcraft offices in Chicago's Merchandise Mart.

Here, fresh, modern and inviting furnishings show at their best under attractive, efficient Corning engineered Unilite lens panels.

Soft, even, over-all light eliminates shadows. Fixture brightness and glare are minimized. Water-white crystal lenses transmit true color from the light source.

More than 1¼ miles of glass panels — in approximately 1600 four-foot, two-lamp troffers — light 66,000 square feet. Average illumination levels are 60-foot candles maintained (at no place could less than 50 f.c. or more than 70 f.c. be found).

Lens panels offer other advantages, too. Installation is easy and economical because of their light weight. And, being glass, Corning lens panels cannot fade, warp or discolor as other materials often do. They add to appearance whether lights are on or off.

Unilite lens panels are only one of several types of Corning engineered glass lightingware. You can also achieve distinctive effects with combinations of flat and curved Twinlite lens panels, Alba-Lite, Fota-Lite, Crysta-Lite and Lenslites.

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Please send me Bulletin LS-32 describing Corning's full line of engineered lightingware.

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congratulations to the ford motor company

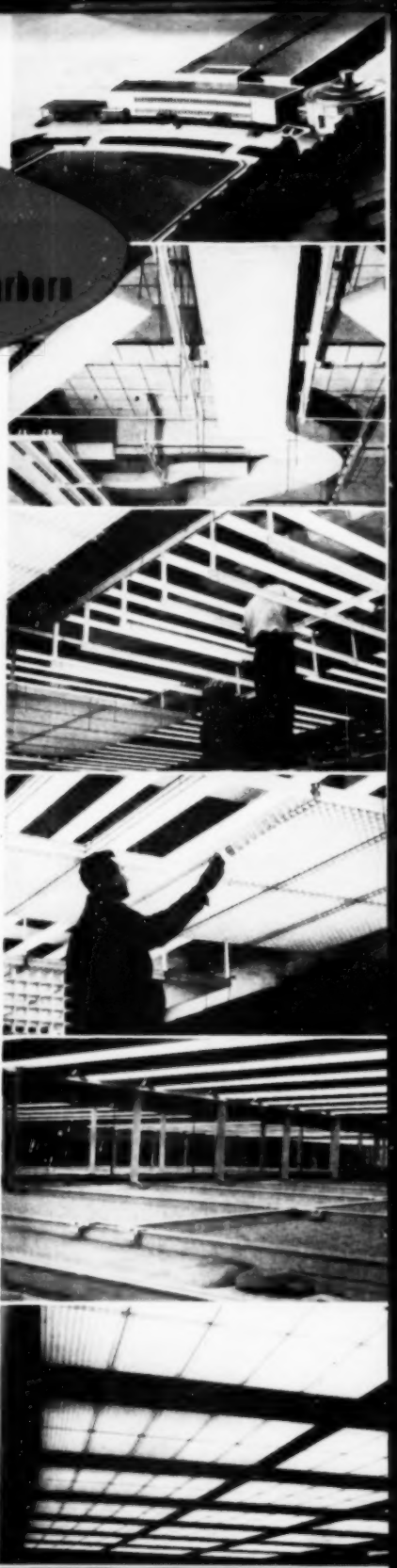
on the beautiful new engineering and research center in Dearborn

Among the notable architectural features in this outstanding new building is the Smithcraft Area Illumination installation of overall lighting.

smithcraft area illumination is today's outstanding expression of an evolution in lighting. For centuries the only light source used by man emitted its illumination **from a point.** With the relatively recent development of **the linear source of light** in fluorescent lighting, higher levels of illumination have become economically practical and lighting has established itself as an important partner of the architect, owner and user.

Now advanced planners in architecture and illuminating engineering are thinking in terms of **area of light source.** Through advanced design and a brand new structural simplicity, Smithcraft Area Illumination has eliminated previous difficulties of installation and servicing. The system is actually one lighting "fixture" when installed. There is no superfluous multiplicity of supports to the ceiling and there are no complicated electrical service connections to clutter the plenum. And, most important of all, Smithcraft Area Illumination is economical, efficient and extremely easy to install.

SEND FOR FURTHER INFORMATION ON SMITHCRAFT AREA ILLUMINATION.



1. Lighting installation covers network of ducts and beams without interference with other services and with a minimum of supports to the ceiling.

2. The electrical element is completely installed and lamps are lighted. Men are installing framework for louvered shielding.

3. Louvers are being installed. Glass, plastic, lens . . .virtually any light diffusing medium may be specified for Smithcraft Area Illumination.

4. View between shielding and electrical element. Plenty of room for efficient lamp replacement. Acoustical metal pans are supported entirely by the lighting installation.

5. Lighting installation conforms to contour of the building. The system permits the architect a new freedom of choice as to size, pattern and shape, shielding, intensity and periphery.

There are three separate installations of Smithcraft Area Illumination in the Ford Engineering and Research Center with a combined area of more than 65,000 sq. ft. Intensities in the three areas are 112, 100, and 108 footcandles.

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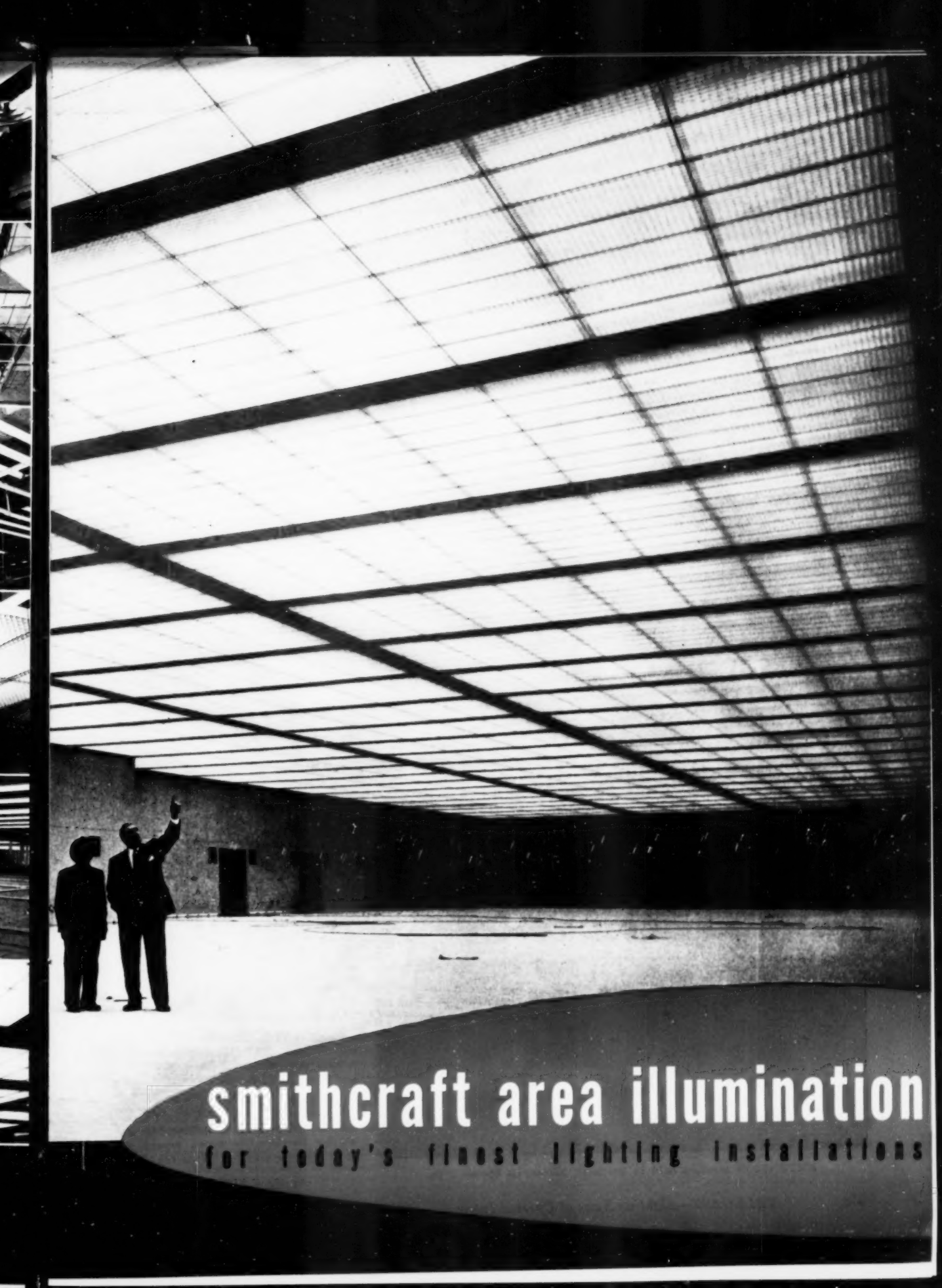
ELECTRICAL CONTRACTORS: Harlan Electric Company, Detroit

DISTRIBUTORS: General Electric Supply Company, Detroit

Smithcraft

LIGHTING DIVISION

CHELSEA 50, MASSACHUSETTS



smithcraft area illumination

for today's finest lighting installations

(Continued from page 20A)

Dr. Murroughs, associate professor of psychology, Northern Illinois College of Optometry, Chicago, described experiments in which various cues to depth perception were tested. He said that where one cue was pitted against others, interposition was found to be by far the most potent. It is commonly used even by amateur photographers and, in the view of Dr. Murroughs, will continue to be one of the most effective, regardless of the elaborate equipment now being perfected by the motion picture industry.

Among other cues are color, light intensity and positions of shadows. In nature or in motion pictures, speed of motion is an important one. A distant airplane, for example, appears to move more slowly through the visual field than a plane which is close.

"Further pastures actually are greener to the eye," Dr. Murroughs said. "Colors lose their purity as light passes through the atmosphere, so that distant objects appear a darker shade of color than similar objects nearby.

"Bright sunlight falling on your lawn tends to produce a yellowish percept, whereas the other fellow's grass is always greener. Trees at a distance appear bluish green."

The atmosphere also makes distant objects appear hazy, according to Dr. Murroughs. In fog, a mountain top appears more distant than it actually is and this, Dr. Murroughs said, may account for many airplane accidents.

In his article Dr. Murroughs reports on perspective cues used by Leonardo da Vinci and other Renaissance painters. He said that until recently scientists assumed that man's perception of depth was dependent on binocularity—the comparison of the different images received by the two eyes which in an adult are about two and a half inches apart. Binocular vision is now considered merely a check on other cues and insofar as can be determined one-eyed persons learn to perceive depth as accurately as those with normal vision.

Seagulls and fishes, according to Dr. Murroughs, learn not only depth perception but also learn to compensate for refractive differences that occur when light passes into or out of water. Their judgment of distance is entirely monocular.

Bibliography on Lighting Available from Headquarters Office

A list of books, publications and periodicals, compiled and kept up-to-date by the I.E.S. Committee on Lighting Education, is available from the Technical Department at I.E.S. headquarters office. Consisting of nine mimeographed sheets, this bibliography on light and lighting covers publications which make a definite contribution to the field of illumination, grouped according to the subject matter which they represent.

These sections are (1) Lamps and Lighting, (2) Architecture and Lighting, (3) Physics of Light—Optics, (4) Color, (5) Light, Eyesight and Health—Related Psycho Physiological References, (6) Trade Papers and Professional Journals in both English and foreign languages.

I.E.S. Extension Meeting Held in Portland, Maine

Despite a heavy rainstorm, an attendance of 106 from a 100-mile radius marked the second joint meeting of the I.E.S. members in Maine and the Electrical Associates of Maine, March 24th at the Eastland Hotel, Portland, Maine.

Perley E. Weatherbee, I.E.S. Local Representative, was general chairman for the program which featured James A. Norris of New York City, who spoke on "Blacklight and Fluorescence." Further discussions and demonstrations with a question and answer period were provided by a panel made up of W. P. Lowell, Jr. and E. F. Lowry, of Sylvania Electric Products, Inc., and L. S. Cooke of General Electric.

EXTENSION meeting held in Portland, Maine, on March 24th.

Focus and Quality Determination Of Searchlight Reflections

A method for determining the focal point and evaluating the quality of searchlight reflectors, developed by W. F. Mullis, J. A. LeRoche and T. H. Projector of the National Bureau of Standards, is fast and convenient, and requires very little space and only inexpensive, readily assembled equipment.

The NBS method for determining focus can be completely set up in a small room requiring little more space than is required by the searchlight itself. It was, therefore, designated the NBS Short Range Method. There are many other methods for determining focal point, some requiring long distances, some applicable within confined spaces, but it has been found that the NBS Short Range Method is either more convenient or more accurate than alternative short range methods.

Although the shadow of an opaque obstruction in a searchlight beam would be congruent to the cross section of the obstruction only under ideal conditions never realized in practice, these conditions may be approximated so closely that under certain restricted circumstances, congruence may be used as a criterion of best focus, and the extent of departures from perfect congruence, as a test of the quality of the reflector. Such approximation is obtained in the NBS Short-Range Method by the use of an extremely small ophthalmic lamp, installed in place of the searchlight's own light source, an opaque mask of special design attached to the reflector and located about $1\frac{1}{2}$ inches from its aperture, and a screen with an accurately traced outline of the mask, located about three feet from the aperture of the reflector. None of the equipment need be made with high precision, and the installation requires only moderate care in alignment. The aperture of the reflector, the plane of the mask, and the screen should be parallel, but this adjustment can be made with only yardstick accuracy. The distances between the mask and the reflector and between the reflector and the screen are not critical. The dimensions of the small coiled filament of the ophthalmic lamp are approximately $\frac{1}{4}$ by $\frac{3}{16}$ inch.

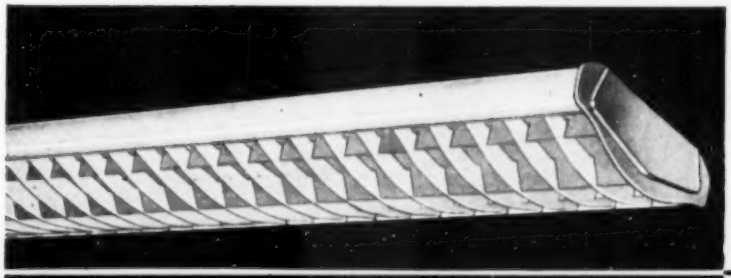
To determine the focal point of the reflector, the projected shadow of the opaque mask is made to fall on the traced outline of the mask on the screen. As the small lamp is moved along the axis of the system, the shadow will expand or contract in size, depending on whether the lamp is moved toward or away from the reflector. When the edges

(Continued on page 27A)

new mitchell fluorescent luminaires

with upward component and low cost efficiency

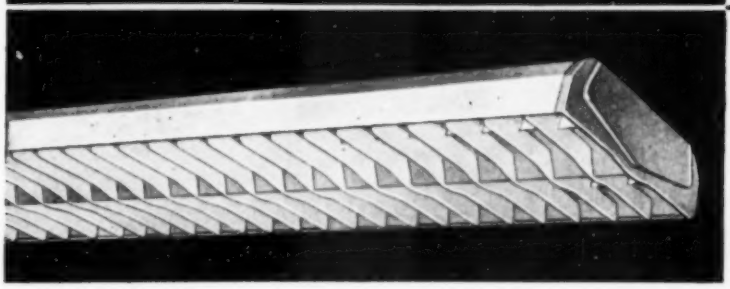
MITCHELL engineering achieves remarkable standards of abundant, glare-free illumination in these new Commercial Luminaires. Important lighting advantages are achieved by the substantial upward component which provides a "general diffuse" lighting effect. The superior louver design delivers properly shielded illumination to the working area. Smooth styling, unusually low maintenance factor and surprisingly low cost make these new MITCHELL Luminaires outstanding values in commercial fluorescent lighting.



the "LODESTAR" luminaires
with translucent plastic sides

4-FOOT MODELS: Available in 2 or 4 lamp luminaires, choice of 40-watt medium bi-pin, 40-watt Instant-Start, 40-watt Rapid-Start, 38-watt Slimline.

8-FOOT MODELS: Available in 2 lamp 75-watt Slimline; 4 lamp or 8 lamp 75-watt Slimline, 40-watt medium bi-pin, 40-watt Instant-Start, 40-watt Rapid-Start or 38-watt Slimline.



the "ECONOMY" luminaires
with metal sides

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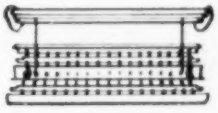
outstanding lighting features and maintenance advantages

These luminaires are of the "General Diffuse" type; approximately half the light goes up to be reflected from ceiling and upper walls to provide comfortable, glare-free, uniform lighting.

New Rapid-Start units offer an unusual advantage: "No starters to replace." Installation of Rapid-Start luminaires slashes maintenance cost by eliminating starter replacement expense.



Two jack chains suspend entire louver and V-spine assembly from fixture body, making relamping easy and substantially reducing maintenance costs. This convenience feature saves time and money.

Sturdy, concealed spring-loaded louver latch instantly releases or engages all-steel louver by snap-in action. Releases with slight pressure of fingers. Simplifies relamping and maintenance.

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devoted EXCLUSIVELY to the
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FLUORESCENT BALLASTS

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(Continued from page 24A)

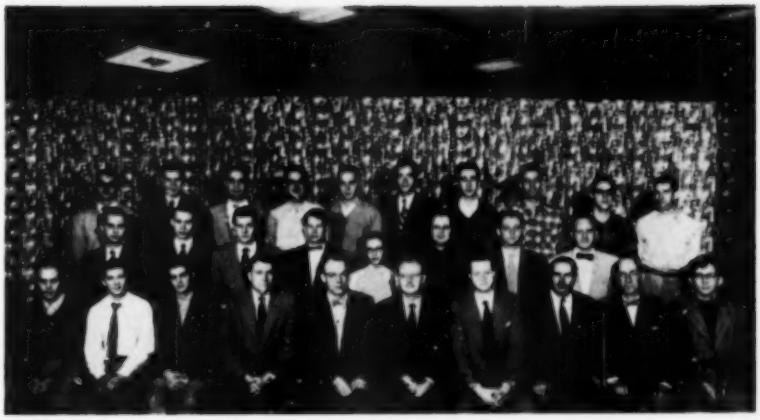
of the shadow (both inner and outer) most closely approximate the traced outline then the filament of the lamp is considered to be at the focal point. The edges of the shadow of the mask seldom coincide perfectly with the traced outline; deviations from perfect coincidence are a measure of the imperfections of the reflector. The sensitivity of the method for determining focal point can be estimated, for example, from an examination of a pattern taken with the lamp $\frac{1}{32}$ inch out of focus and a pattern taken with the lamp in focus. It has been found that the focal point can be determined easily to within $\frac{1}{4}$ inch.

In using the NBS Short-Range Focusing Method, it should be kept in mind that only a relatively small fraction of the total area of the reflector is actually utilized in the determination. This consists of the thin strips on the reflector that contribute to the formation of the edges of the shadow of the mask. As in any sampling technique, the validity of the sampling must be established. A study of the searchlight reflectors for which the method was developed showed that the major departure from parabolic form was characteristically a function of the radius of any sampled area, and that the focal points of all the zones in any thin circular strip (symmetrical about the axis) were constant. The mask was therefore designed in such a way as to provide a sampling of areas of the reflector with a considerable range of radii. Any of a variety of masks may be used, and they should be designed in each case to provide a sampling of reflector areas suited to the characteristics of the particular reflector used.

The projected shadow pattern reveals reflector imperfections clearly. In addition to the distortion revealed by deviations between the edge of the shadow of the mask and its traced outline on the screen, an examination of the edge of the beam and of the appearance of the unshadowed areas within the beam will clearly show excessively prominent grinding marks, bumps or hollows, distortions due to thermal or mechanical stresses, etc. While to a limited extent, reflectors may be examined visually for such distortions, they are very much more difficult to detect in this way. Moreover, with the projected shadow pattern, quantitative analysis of the defects may be made quickly and accurately.

Home Design Is Subject of A.I.A.-I.E.S.-S.I.D. Student Contest

The design of a home, with emphasis on its lighting, was the 1953 prize problem of the jointly sponsored student competition in Cleveland. In its fourth successful year, the Cleveland Section's active Committee on Allied Arts worked with the School of Architecture of Western Reserve University and the Cleveland Institute of Art and the Allegheny Chapter of the Society of Industrial Designers.



TWELVE architect-designer teams visited Nela Park for lighting lectures in preparation for Cleveland's Fourth Annual A.I.A.-I.E.S.-S.I.D. Student Competition. They are shown here with members of the Competition General Committee.

More than 200 members and guests attended the April 15 meeting at the University Club. K. A. Staley presented certificates of merit and the $80 first prize to the architect-designer team of James Kozel and Ernest Schwartz; second prize, $60, to Charles Rimer and William Bonner; third prize, $40, to William va de Velde and G. Bishop King.

In addition, three prizes of $20 each per team were presented to Milan Srnka and Joseph Romelfanger for the Best Architectural solution; to Andrew Burin and Richard Rohrich for Best Illumination solution; to Carl Putzier and Walton Sparks for Best Interior Design solution. The jury consisted of J. Byers Hays and John Bomebrake for A.I.A., Miss Mary E. Webber and Norman Vacha for I.E.S. and Sam Scheer for S.I.D.

Guest speaker of the evening program was Ralph Evans, Eastman Kodak Co., who gave a kodacolored slide lecture, "The Expressiveness of Color."

IT SEEMS TO ME

In the lead article, "Taste," in the April *Journal of the American Institute of Architecture*, among other points on the subject as applied to houses and stores, Gordon Allen, F.A.I.A., describes the fluorescent lamp as "the most horrible invention of all, giving forth a flickering glare guaranteed to ruin your eyes in one painful year or less."

Mr. Allen's diatribe may be based on experience in his own buildings where he has been powerless to control the quality of the luminaires installed by the lessees. But it's no overstatement to say that many fluorescent lighting systems in stores and offices are glaring.

Most fluorescent hit or miss lighting is also subject to criticism for lack of good taste. Only the well-done ones have acceptable artistic style. Economics is probably the principal reason; small companies say they cannot afford the services of good designers and the results are not good for those who buy. You could say, too, that it took nearly fifty years for incandescent lighting to reach a reasonably artistic excellence. It had a glaring beginning, too. Fluorescent lighting is about 700 weeks old.

What can the I.E.S. do to help? Let us first acknowledge two things: (1) in recent years we have had no nationally recognized activity in the fields of art and architecture, and we should; (2) we do not generally recognize illumination as *part* of the design and architecture of buildings, and we should. On the first point, our list of Official Representatives to Other Organizations doesn't include either the American Institute of Architects, the Society of Industrial Designers, the College Art Association, or the Society of Architectural Historians. We do not have a national Committee on Allied Arts. A Cleveland member recently pointed out that "the majority of our meetings consist of our own members talking to our own members about our own stuff."

Historically, the decadence of architecture in past centuries was said to be due to the lack of understanding by architects of their allied craftsmen. But cooperation is a two-way street. One of the answers to today's faulty lighting

(Continued on page 28A)

(Continued from page 27A)

could be the lack of appreciation and knowledge of art and architecture by us craftsmen.

In one sense, Mr. Allen's castigation seems a little like blaming the T-square for the box-like houses being built today. In the wrong environment any lamp can be glaring. In 700 weeks fluorescent lighting has come a long way, but fortunately the way is yet longer. All lighting in interiors can be made more safe for eyes by adopting principles of better design — better architecture.

We should welcome the sympathetic help of the architect and the industrial designer as well as his criticism. Those Sections and Chapters who have worked with allied groups know that it pays. May their tribes increase. — K. A. STALEY, *General Electric Co., Nela Park, Cleveland, Ohio.*

ABOUT PEOPLE

Eugene W. Beggs, manager of the Westinghouse fluorescent and mercury lighting sections, was one of the leading speakers at the international convention of l'Association Francaise des Eclairagistes, in Dijon, France, May 9-17. Mr. Beggs spoke on "American Trends in Electric Discharge Lamps," detailing the growth of fluorescent and mercury lighting in the United States.

The elections of **Don G. Mitchell** as Chairman of the Board of Directors and **H. Ward Zimmer** as President of Sylvania Electric Products Inc. have been announced by the Board of Directors. Both officers assume their new duties immediately and have headquarters at the New York City executive offices. Mr. Mitchell, who has been President of the company since 1946, succeeds as Chairman, **Max F. Balcom,** who will continue to serve the company as a Director and in a consultative and advisory capacity. Mr. Zimmer has been Executive Vice President since 1950 and for three years prior to that was Vice-President in charge of operations.

Rollo Gillespie Williams, authority on color and lighting, is now an industrial consultant in lighting. His address is 20 Clent Road, Great Neck, N. Y.

George L. Jaeger, product specialist in the Westinghouse Lamp Division's commercial engineering department, has been appointed a district engineer in the northwestern district with headquarters in Chicago.

Max D. Gruber has been named New York representative for Eastern Fixture Co., Boston. Mr. Gruber's office is at 235 W. 58th St., New York, N. Y.

Nine electrical engineers have been elected Fellows of the American Institute of Electrical Engineers by its board of directors. They are **J. W. Allen,** Eclipse Pioneer Division, Bendix Aviation Corp.; **A. G. Clavier,** Federal Telecommunication Laboratories; **A. A. Nims,** Newark College of Engineering; **K. M. Smith,** Commonwealth Edison Co.; **J. C. Woods,** Commonwealth Edison Co.; **W. W. Wishard,** Commonwealth Edison Co.; **M. H. Pratt,** Niagara Mohawk Power Corp.; **G. B. Scheer,** Kaiser Industries; **Demitri Trone,** General Electric Co.

The St. Louis Section of I.E.S. is proud to welcome as a member **Dr. Cristjo Cristofv,** Doctor of Engineering, who is currently doing research on surgical lighting systems, incubation, and an orthopedic table for the Shampaine Co., St. Louis, Mo. Dr. Cristofv is the author of many scientific works and has received honors from several European universities. He is now also acting as a consultant for the United States Air Force on some technical matters.

The Strickland Electric Co., 1427 East 18th Ave., Columbus, Ohio, operated by **C. J. Strickland,** has been appointed as local distributor of Westinghouse ultraviolet lamps.

Walter W. Wendelken has been appointed director of works engineering for the Headquarters Manufacturing Division of Westinghouse Electric Corp. Mr. Wendelken, who has been with the company since 1917, was appointed chief electrical engineer of the works engineering department in 1949, from which position he comes to his new assignment.

Sidney P. Lipkins, president of Broadway Maintenance Corp., lighting and electrical construction and maintenance company, was presented with a silver plaque by the Broadway Association, Inc., to mark his 25 years of lighting service.

The appointment of **Joe Poliatschek** as a lighting specialist to serve architects and lighting engineers in Texas, Louisiana, and Oklahoma from headquarters in Dallas, Texas, has been announced by Globe Lighting Products, Inc., Los Angeles.

The McKee Glass Division, Thatcher Glass Manufacturing Co., Inc., has appointed the firm of **Cahill & Galbraith,** 205 Terminal Sales Building, Seattle, Wash., as their northwestern representatives. They will operate under the direction of Pacific Coast Territory Manager, **John B. Miller** of Los Angeles, Calif.

E. S. Dunch, manager of the Merchandise Department of Bermuda Electric Light Co. Ltd., Hamilton, Bermuda, will represent his company at the British Industrial Fair.

Sylvania Electric Products Inc. has appointed **Charles W. Reinhart** as Advertising Manager for fluorescent fixtures of their Lighting Division. Mr. Reinhart will have headquarters at the New York City executive offices.

Coy C. Jordan, member of the Carolinas Section who has been serving in the United States Navy, is returning to civilian life and his job as commercial sales supervisor with the Carolina Power and Light Co. in Raleigh, N. C.

C. A. Badeau, chief engineer of the Thomas & Betts Co., has been appointed to the codes and standards committee of the National Electrical Manufacturers Association. He is also chairman of N.E.M.A.'s electrical power group and of its conduit fittings section technical committee.

The Society records with regret the recent death of two members. **C. E. Loomis** of Corning Glass Works, member of the Chicago Section, died recently after two months' illness. **Albert T. Bergeron,** of the Northern California Section, field sales representative for the Illuminating Division of the Miller Company, died May 3.

BOOKS AND PAMPHLETS

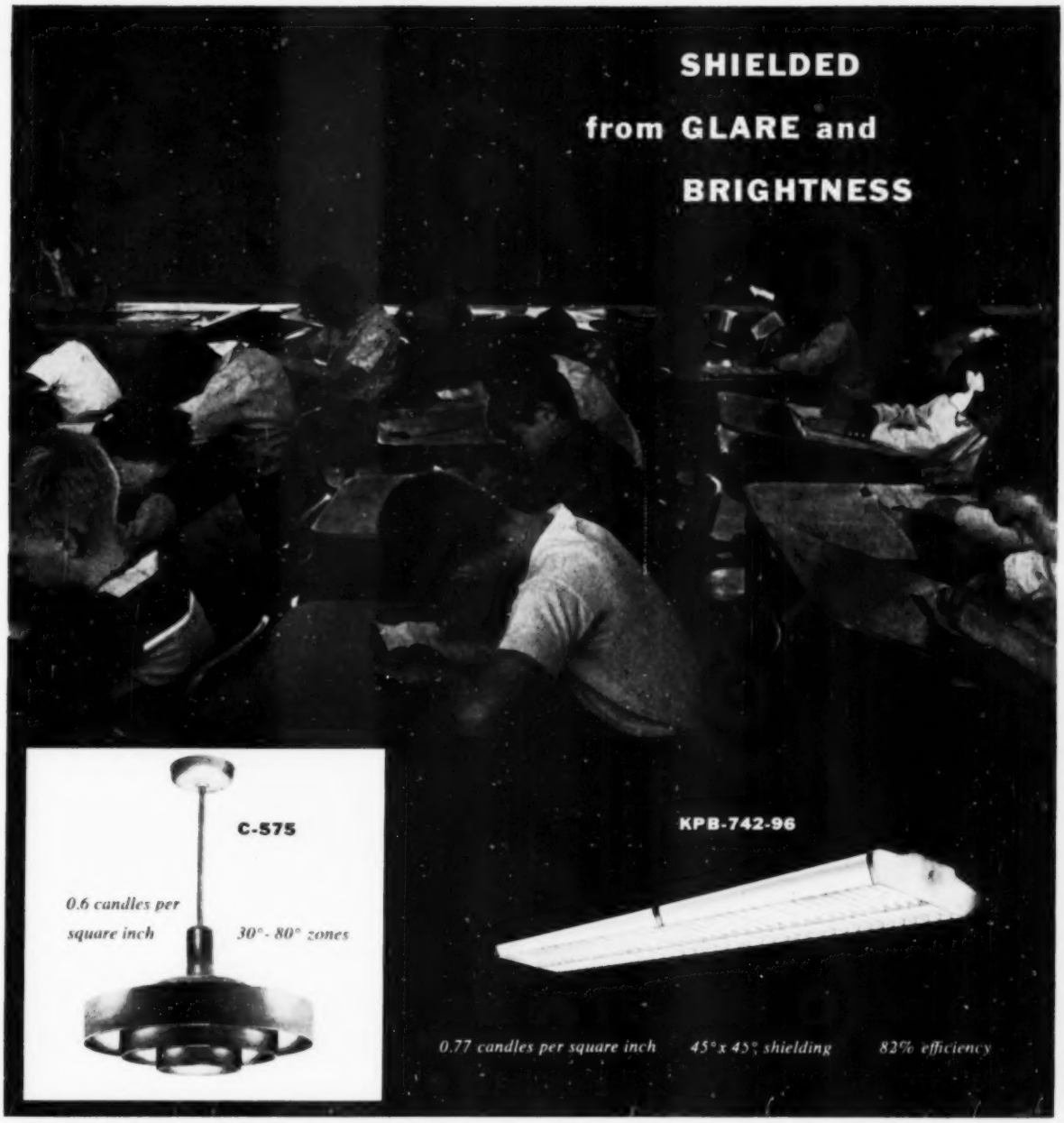
*Books whose reviews are marked * are available for inspection at Headquarters Office, Technical Dept.*

Why Chalkboard Lighting in Schoolrooms?, a new nine-page illustrated booklet, by Leonard V. James, illuminating engineering consultant, discusses proper lighting in schools. Among the subjects covered are the effects of glare to the eye, light distribution over the chalkboard, tasks at the chalkboard and the development of a new chalkboard light. This booklet is available, free, from Solar Light Manufacturing Co., 1357 South Jefferson St., Chicago 7, Ill.

***Lichttechnik** by Walter Köhler, published 1952 by Helios-Verlag GMBH, Berlin—Borsigwalde, Germany; 600 5¾ x 8¼ inch pages, 394 illustrations, 47

(Continued on page 35A)

SHIELDED from GLARE and BRIGHTNESS



C-575

0.6 candles per square inch

30°- 80° zones

KPB-742-96

0.77 candles per square inch *45°x 45° shielding* *82% efficiency*

Where balanced brightness is essential to your lighting plan ideal solutions are offered by Globe's concentric ring incandescent – or – fluorescent and slimline "Classliter."

Write for complete details and photometric data.

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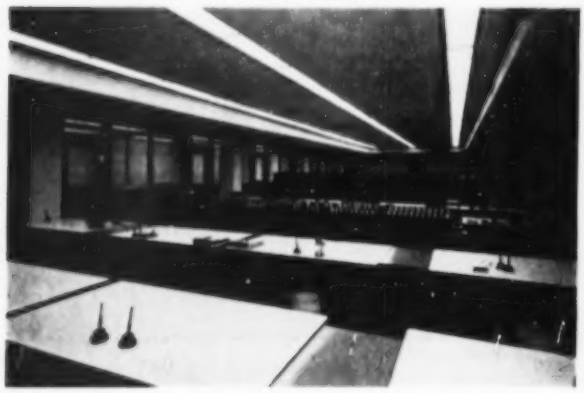
Create the Mood with

LITECONTROL

For Selling, Litecontrol Fixture No. 5928 puts products in their *best* light. Holophane low-brightness lens furnishes even illumination. Removes all glare and sharp contrasts. Simple, smart and efficient. Also available with diffusing glass panels.

For Displaying masterworks in this Art Museum, Litecontrol paints the scene with F-74 4-lamp fixtures. "Custom" in appearance and performance only, modified "standard" design makes them exceptionally economical.



For Working, Litecontrol keeps busy eyes sharp in this office with No. 5124 and No. 5128 2-lamp fixtures. Smart and unusually efficient. Holophane CONTROLENS prevents glare and sharp contrasts. Hinged door frames open or close *at the snap of your fingers* — on exclusive Litecontrol *Trigger Catch* snap-locks.

For Learning, Litecontrol Fixture No. 4624 helps pupils see through the tough ones. Good looking, eighty-six per cent efficient, its low initial cost and simple maintenance make it popular for classrooms.

•

There's a LITECONTROL Fixture for every scene and situation. You, too, can have "custom" beauty and performance at "standard" prices. Write for catalog and complete information.

LITECONTROL

Fixtures

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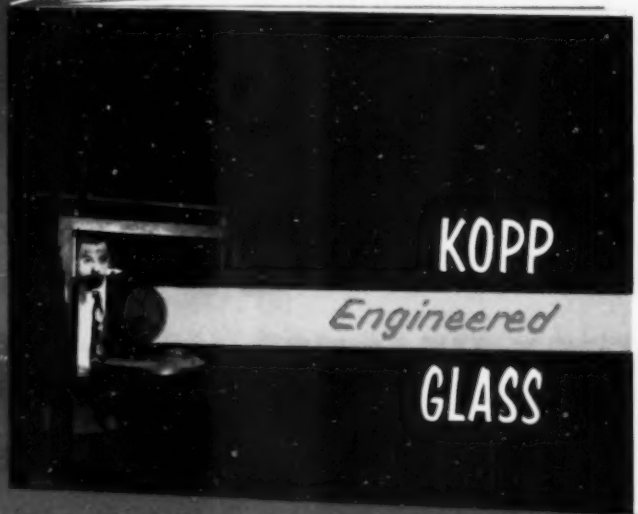
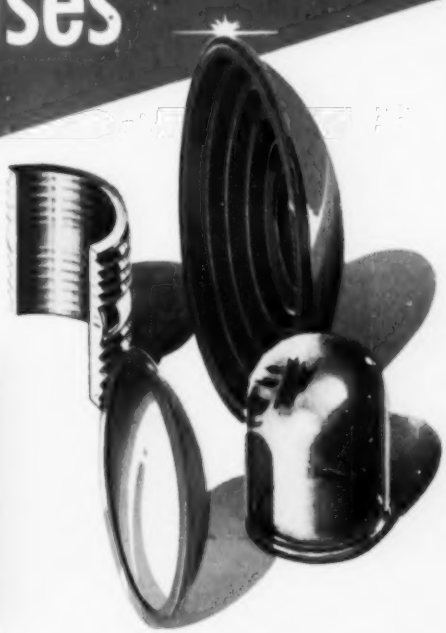
New light on lenses

and other glass products . . .





This new brochure now available . . . Send for a copy.

New useful data on Kopp engineered glass products is given in the brochure shown above. It describes a wide variety of lenses, color filters, cover glasses, globes and other items designed by Kopp engineers, and shows the manufacturing processes by which Kopp products are made.

Each of the Kopp products described has been designed to fulfill the requirements of some specific application. A study of the brochure shows the possibilities of expertly designed and carefully made glass parts in many fields and applications.

May we send you a free copy of this thought-stimulating booklet?

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KOPP GLASS, Inc.
SWISSVALE, PA.

KOPP GLASS, INC., Swissvale, Pa.

Please send a copy of KOPP ENGINEERED GLASS (Bulletin K-353) to:

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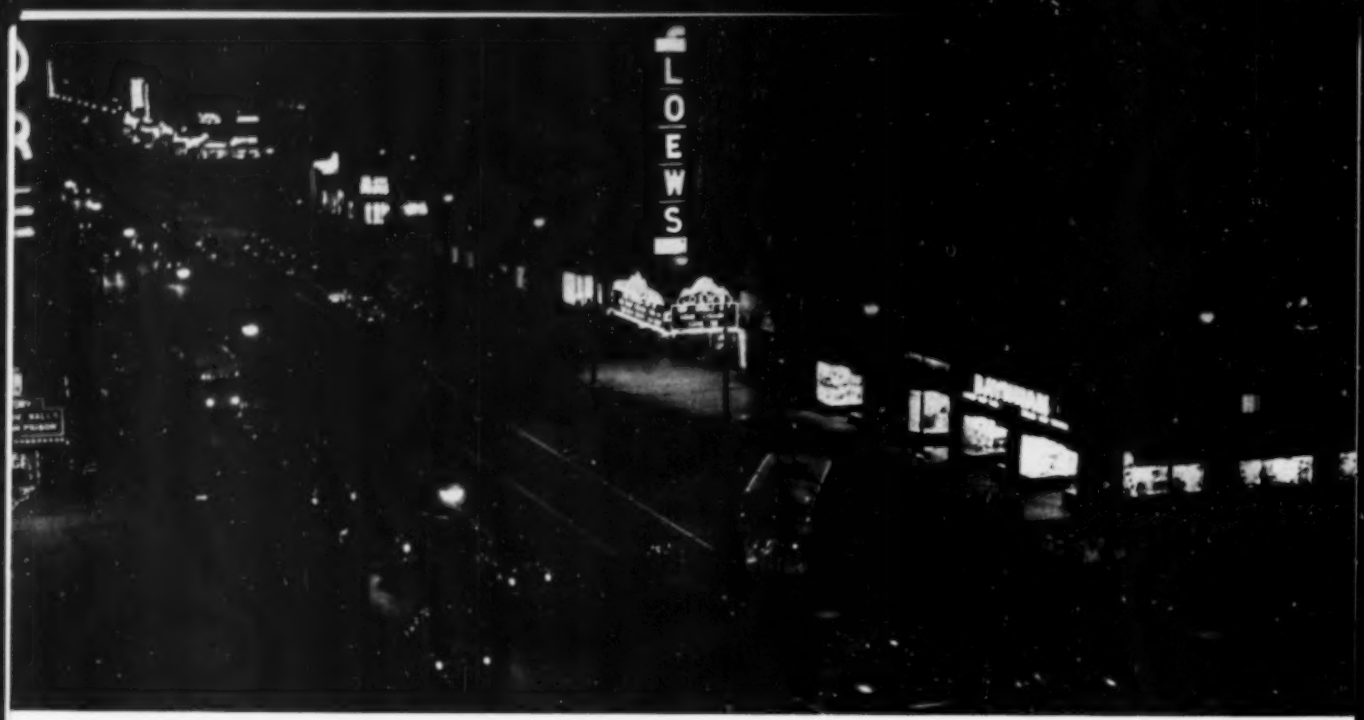
Title _____

Company _____

Address _____



TRAFFIC MOVED FASTER with less strain on drivers and pedestrians when downtown light levels were increased more than 300 per cent. New lights were installed on primary and secondary thoroughfares and residential streets in order of need for lighting protection.

LIGHT LEVELS were recorded and used in assigning relighting priorities to city's business and residential streets.

EFFECTIVE STREET LIGHTING

Vast Dayton Power and Light program

Dayton, Ohio, is saving hundreds of lives, increasing property values, and decreasing its crime rate with modern relighting of the city's streets. Under a plan described by safety officials as the "most functional in the world," Dayton has become one of the most effectively lighted cities of its size in the country.

The plan gives top priority to streets where pedestrian and automobile traffic is heaviest. It utilizes filament, sodium, and mercury-vapor luminaires, each applied where its advantages can best be used.

The first relighting doubled illumination in the downtown business district, an area of over five square miles. Other streets followed, on a priority basis, and the relighting program is continuing.

How Dayton achieved its bright, safe streets and some of the benefits they have brought is told in the picture story on these pages.

G-E LIGHTING ENGINEERING is helping to relight thousands of miles of streets all over America, making communities safer, more pleasant places to live.

DARK STREETS caused accidents which spurred drive for better lighting to eliminate this major cause of traffic toll. Surveys have shown that each night traffic fatality costs a community $65,000.

RELIGHTING PLAN is studied by J. E. Hess, G.E. Co., H. S. Nonneman, Dayton Power & Light Co., plan's originator, Mayor Lohrey, former City Manager McClure. Relighting cut night accidents 40%.

MORE BUSINESS came as crowds of evening shoppers were drawn by bright, safe streets. Stores started profitable evening store hours. New ventures were encouraged. Daytonians enjoyed more shopping time.

MAKES DAYTON SAFER

helps business, cuts accidents

Your electric utility can call on General Electric's services for planning and consultation, just as Dayton's utility has done. Vitally interested in your community's welfare, your utility has the know-how to help you modernize your street lighting quickly and economically.

If you would like booklets on how to plan and promote better street lighting in your community, write Section 452-132, General Electric Company, Schenectady 5, New York.

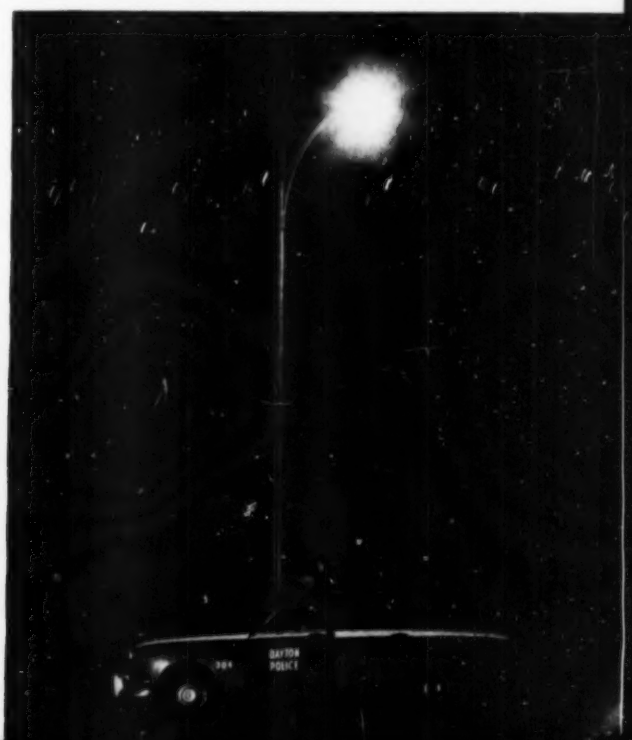
You can put your confidence in—

GENERAL ELECTRIC

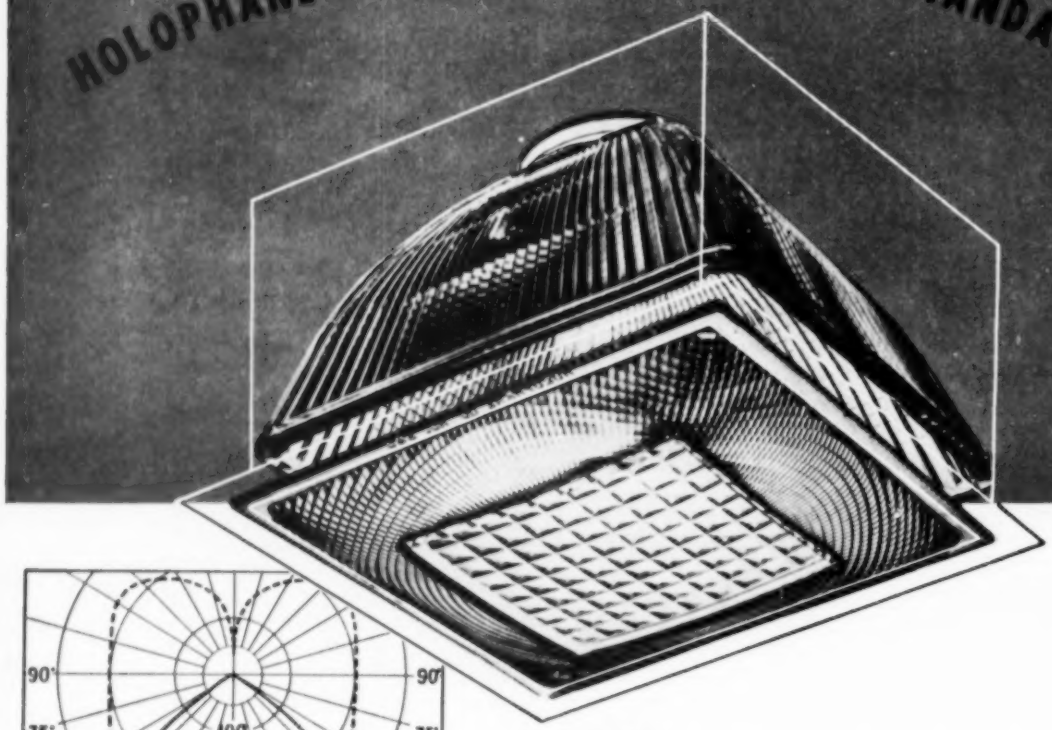
NO MORE FEAR for pedestrians at night, after relighting. Proud of bright, cheery streets, they welcome the end of robberies and molestations, feel safer in residential sections after dark.

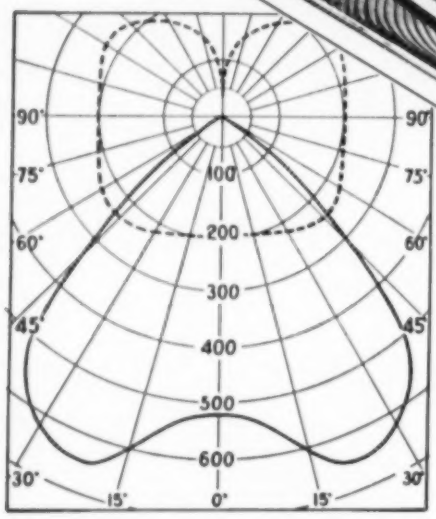
PROPERTY IS SAFER. Dayton police and fire departments report that the new street lighting enables them to move faster and more efficiently to prevent property losses by fire and theft.

HAZARD AREAS, such as this railway crossing, were specified by Police Department, given priority and special attention. Use of specially arranged standard lighting units provided safer, brighter light patterns.



HOLOPHANE-ENGINEERED TO SET NEW STANDARDS





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Elegant and Efficient Lighting for

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540 SERIES . . . Featuring the New *Dished* INCANDESCENT CONTROLENS*

- **SCIENTIFICALLY DESIGNED . . . by Holophane Engineers, these units provide (1) high output (2) controlled distribution (3) minimum glare.**
- **NEW PRISMATIC PATTERN . . . of the drop-trim Dished CONTROLENS produces the utmost in architectural beauty as well as effective illumination . . . intensive light pattern . . . 1.25 spacing ratio.**
- **MODERN CONSTRUCTION . . . conveniently sized to fit standard acoustic block. Available in two depths—8⅞" and 4½"—for normal and shallow headroom.**

Architects, engineers and contractors are invited to write for complete data, without obligation.

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THE HOLOPHANE COMPANY, LTD., THE QUEENSWAY, TORONTO 14, ONTARIO

(Continued from page 28A)

tables; price 22.50 German Marks (approx. $5.35). Subject: Current lighting practice in Germany; text in German. Topics treated include A. Evaluation of Lighting: light source as transmitter, eye as receiver, degrees of efficiency of light production, units and nomenclature, photometry, color measurement and color vision; B. Production of Light: light sources; C. Lighting Technology: illumination and vision, daylighting, artificial lighting design, lighting applications — offices, drafting rooms, outdoor arenas, street lighting (much fluorescent), airport, industry, stage lighting, photography, projection, erythemal and infrared, residence lighting, public buildings, indoor sports, restaurants, museums and art galleries, churches, theaters, architectural lighting, advertising (stores, store windows, signs); D. Economics. The book is concluded by a bibliography of 65 books and 275 papers published in the U. S. and Europe, although mostly German.

Engineering — A Creative Profession, a 32-page booklet published by the Engineers' Council for Professional Development, is a comprehensive guide to the choice of a career in one of the several fields of engineering. The types of work involved, requirements in aptitude and education, opportunities in the field and the organization of the profession are covered. The booklet, which replaces the Council's "Engineering as a Career," is available at 25 cents per copy from the Engineers' Council for Professional Development, 29 West 39th St., New York 18, N. Y.

Rear Lights of Motor Vehicles and Pedal Cycles, 22-page illustrated booklet, is a report from the Department of Scientific and Industrial Research, Road Research Laboratory of Great Britain. An analysis was made of the records of accidents of pre-war and post-war cars where rear lights were a factor, and a survey was undertaken to determine reliable statistics on the effects of mounting height, candlepower and performance of specific lamps and reflectors. The Road Research Technical Paper No. 25 is available from the Department of Scientific and Industrial Research, 5-11 Regent Street, London, S. W. 1, at 40 cents each, plus postage.

. . . **And a Voice Shall Be Heard** is a new Civil Defense communications motion picture available in 16mm and 35mm sizes, for use by governmental or

(Continued on page 36A)

school:

THE MILLER LEXINGTON fluorescent luminaire offers these important advantages:

LIGHTING—highly efficient with extremely low brightness for true visual comfort.

ECONOMY—easier, quicker installation, and low maintenance — *low overall cost* (of fixtures, installation and maintenance the *true cost*). Achieved by new engineering features. More for your school lighting dollars. Write for details.

DESIGN: *Functional—clean, simple lines.*

EASY *2-way lamping—1 ladder position.*

STRENGTH: *Rigid 1-piece steel louver.*

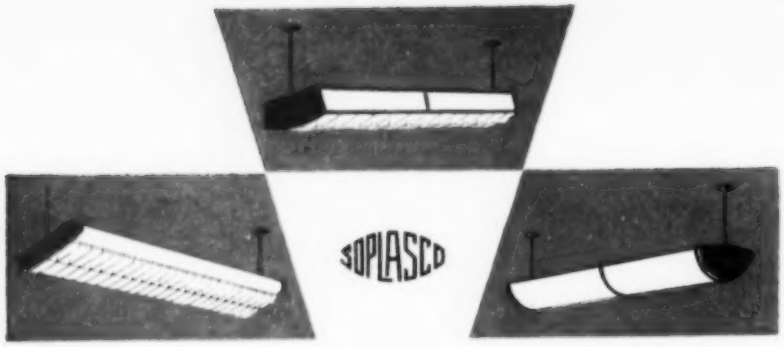
THE **miller** COMPANY *Meriden, Connecticut*

LEADERS IN LIGHTING SINCE 1844

(Continued from page 35A)

private organizations to promote Civil Defense programs. Made by the March of Time for the General Electric Company, the 16mm versions are obtainable from that company's 18 film libraries. Loans of the film are without charge. The 35mm film for theatrical or auditorium showings are available only upon direct request to General Electric Co., Motion Picture-Television Department, Bldg. 23, Schenectady 5, N. Y. Copies may be purchased in either size: 16mm for $35; 35mm for $85.

Occupational Safety Service Guide, 52-page booklet 2.1 published by the National Safety Council, provides company safety directors with a complete catalog of the many accident prevention aids available from the Council. For the safety man, it offers the Council's periodicals, newsletters and a library of technical and administrative publications covering occupational accident prevention. Information on the subjects covered in the basic and advanced courses of the Council's Safety Training Institute is also included. To assist the foreman, the service guide offers a monthly magazine, 24 training films that show



PLASTIC PANELS

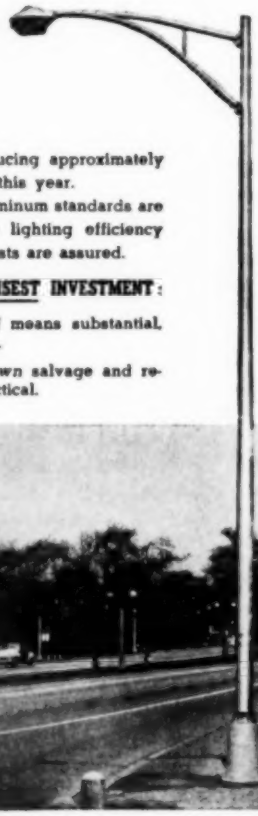
Southern Plastics Company stands ready at all times to work with your designers and engineers.

Southern Plastics is equipped to develop an extrusion or mold to your specifications or to design the extrusion or mold to fit your needs, as they have done for the largest lighting fixture manufacturers in the world.

SOUTHERN PLASTICS Co.

408 Pendleton St. Columbia, S. C.

the PFAFF & KENDALL Story in Chicago Parks...



Special 28' tapered All-Aluminum standard with 8' overhead lighting upsweep arm on Lakeshore Drive, made to Chicago Park District specifications.

(Photo courtesy Chicago Park District)

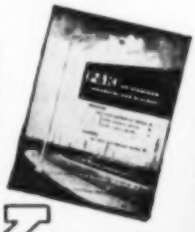
Nature's beauty now combines with the last word in functional, economical lighting standards in the parks of Chicago. Aluminum standards were first installed in May 1946 and as of February 1953, there were 700 in use. Pfaff & Kendall is presently producing approximately 1700 more for installation this year.

Wherever P & K All-Aluminum standards are installed, up-to-the-minute lighting efficiency and lowest maintenance costs are assured.

WHY P & K ALL-ALUMINUM STANDARDS AND BRACKETS ARE ALWAYS THE WISEST INVESTMENT:

- *Much lighter weight* means lowest installation cost.
- *Negligible rate of corrosion* provides longest life.
- *No painting required* means substantial, continuous savings.
- *In event of knock-down* salvage and reuse is entirely practical.

WRITE FOR LATEST P & K CATALOG... AND USE THE P & K PLANNING AND ADVISORY SERVICES WITHOUT OBLIGATION.



Pfaff & Kendall

84 Foundry Street
Newark 5, New Jersey

supervisors how to use basic human traits in building a better safety program and several hundred five-minute safety talks. Copies of Service Guide 2.1 can be obtained without cost from the National Safety Council, 425 N. Michigan Ave., Chicago 11, Ill.

A 25-page revised version of the mercury vapor lamp booklet, A-5112, is available from Westinghouse Electric Corp. The booklet includes information on both the fluorescent-mercury and straight mercury type lamps. In addition to application and performance data the pamphlet discusses lamp and lumen maintenance, lamp temperature and ambient temperature. Copies are available from Westinghouse Lamp Division, Mac Arthur Ave., Bloomfield, N. J.

NEW MEMBERS

At the meeting of the I.E.S. Council Executive Committee, held in Baltimore, Md., on May 13, the following were elected to membership:

ALABAMA CHAPTER

Member:

Overton, E. C., 2111 Warrior Rd., Birmingham, Ala.

Associate Member:

Haunum, W. H., Alabama Power Co., Birmingham, Ala.

ARIZONA CHAPTER

Associate Members:

Downey, M. W., Arizona Public Service Co., Phoenix, Ariz.

Eaton, E. A., Arizona Public Service Co., Phoenix, Ariz.

Godemann, R. W., Arizona Public Service Co., Globe, Ariz.

Savoy, W. M., Arizona Public Service Co., Phoenix, Ariz.

Waggoner, L. E., Jr., Arizona Public Service Co., Phoenix, Ariz.

CAPITAL SECTION

Associate Member:

Endres, L. M., Public Building Service, Washington, D. C.

CAROLINAS SECTION

Member:

Marvin, H. W., Jr., Westinghouse Electric Supply Co., Raleigh, N. C.

Associate Members:

Bumgardner, S. R., Westinghouse Electric Corp., Winston-Salem, N. C.

Meacham, T. B., General Electric Co., Charlotte, N. C.

Welker, V. C., Jr., General Electric Supply Co., Greensboro, N. C.

CENTRAL NEW YORK SECTION

Associate Members:

Barnes, B. B., Corning Glass Works, Corning, N. Y.

Donaldson, J. B., Sylvania Electric Products Inc., Salem, Mass.

(*Continued on page 38A*)

IT'S ABOLITE

FLOODLIGHTING TIME

The greatest selection of styles and types for every purpose.

Get the right floodlights from your wholesaler. Get ABOLITE.

ABOLITE Lighting DIVISION

THE JONES METAL PRODUCTS CO.
WEST LAFAYETTE, OHIO

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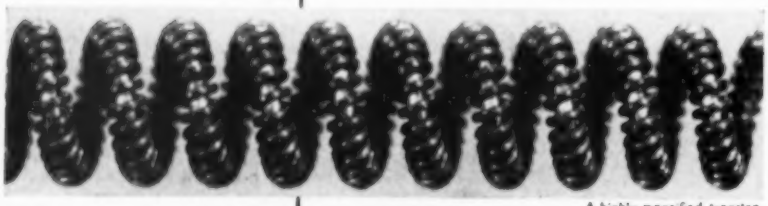
FACTS OF LIGHT



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A 6 watt lamp filament is made from tungsten wire drawn to a diameter of .00047 inch — about 1/7th of the diameter of a human hair. A variation of five-millionths of an inch can affect filament life as much as 25%.

Backing up the heart of a Champion are long years of production experience. Carefully selected Champion electrical and industrial suppliers — there's one in your vicinity — assure you of the utmost in lighting value and service when you specify Champion lamps.

May we mail you a copy of this new booklet L, CHAMPION QUALITY, containing many other facts about lamps?

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Lynn, Massachusetts

A DIVISION OF CONSOLIDATED ELECTRIC LAMP CO

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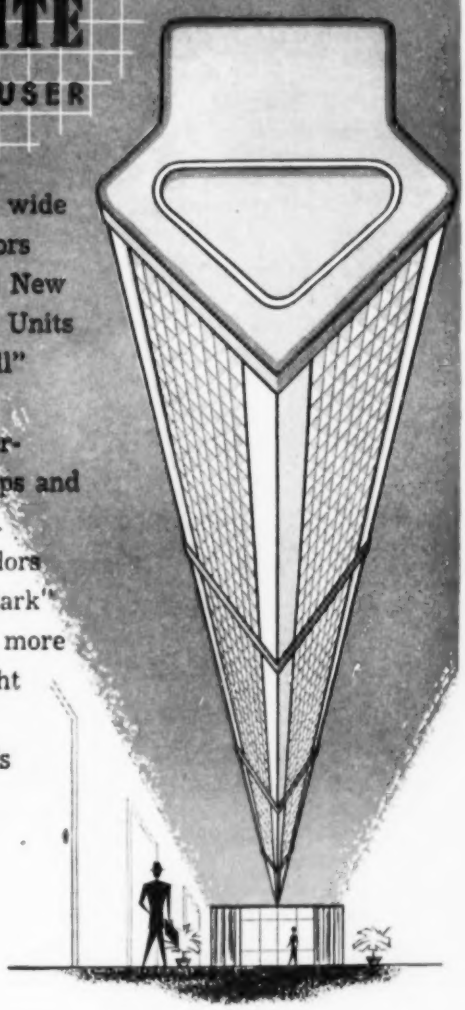

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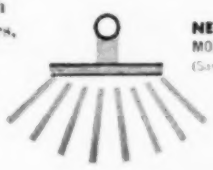

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